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Design of Castings and Foundry Workmanship

We have lately been reviewing mentally some of the decisions given in the High Courts of Justice in cases where the suitability of some castings supplied have been questioned. In many instances the cases revolve around design. Only last week an action was heard, and in this case the learned judge, said he was convinced that the design of the casting was satisfactory because it had been shown in evidence that large-scale deliveries from other foundries had caused no trouble. We have received the impression that, in general, foundries are unlucky with this type of High Court action. This may be due to the fact that disputed castings are not common interchangeable merchandise. By this we mean, if some rain-water goods were in dispute as to quality, it would not be necessary to call in expert witnesses, but only a disinterested merchant who would or would not make a bid for them and thereby settle the issue. In the matter of engineering components, however, it is a case as to whether the purchaser will or will not accept them and if the decision be against the foundry, then in all probability there remains but the remelting value. From a study of such cases, we think we are now in a position to give some advice as to their future avoidance. Primarily, there must be a recognition of the fact that certain foundries are specialists in the production of some lines of castings to such an extent that they well-nigh produce the impossible. The jobbing foundry of to-day would find it very difficult to produce a motor vehicle cylinder to the specifications of the large companies, even though they employed the most highly-skilled moulders available. The next feature is the design of the casting accompanying an inquiry. Before quoting, there should be a most definite assent from the foundry executive that the casting enters easily into the ambit of the skill of his moulders and the facilities available for its creation. Then where great complexity of design exists, which tends to leave stressed members, a resort to annealing before even fettling may swing the balance in favour of accepting an order.

It seems rather useless in law to deny knowledge of the use to which a casting is to be put, for the legal luminaries invariably introduce the question of "warranty." The foundry which furnished the "singing propellor" would scarcely have had in mind when they supplied the casting that it would be suggested that such an extraneous matter as "singing" would be put forward as good grounds for non-acceptance by the buyer. It would appear that again design was a major factor, and this of course is not directly a matter for the foundry, but there seems to be a tendency to establish that no matter how crude or defective the design, once the order has been accepted, it must be presumed that the foundry fully appreciates all phases of its industrial application. Moreover, the old rule that liability ends with the replacement of a casting proved to be defective within reasonable time does not always hold good. Suppose a series of, say, six have been delivered and the first three were deemed to be wasters. Here the buyer apparently can cancel the order by presuming the last three to be also imperfect and likely to fracture on machining or burst under pressure. The law realises that the buyer has received no benefit—(the reverse in fact), from the first three castings delivered and upholds him in his refusal to risk more money on the balance of the consignment. It appears to us that for the ordinary run of orders, the sales conditions as set out by the intelligently operated foundry are adequate, but when dealing with castings of special complexity, the increased risks involved call for additional disclaimers of liability. For instance, accompanying a letter of acceptance of the order, a paragraph might usefully be inserted to the effect that *should any claim arise from the execution of this order involving a difference of opinion as to whether a defect is due to foundry workmanship or design, it shall be deemed to be due to design, over which the seller has no control and therefore cannot accept any liability.* Such a disclaimer would make the buyer re-examine his design or produce convincing evidence that no difficulties had been experienced in their manufacture by other concerns.

It is not pleasant to stress these legal aspects, for it is obvious that by fuller co-operation resort to law would be much less frequent. There will always be those awkward third party cases, where the buyer of the castings is involved in legal action with the ultimate consumer and passes the ball back to the foundry. One case is on record where a foundry, contrary to normal legal equity, were mulcted for a substantial amount of consequential damages, because a ship could not go on its voyages. This, so far as the lay mind can understand, was because the intermediary party had admitted liability for late delivery and then instituted an action to recover what was virtually "agreed damages."

Autumn Metal Prospects

BY "ONLOOKER."

August is *par excellence* the holiday month and business people expect that at this time of the year there will be a lull in affairs and a general slowing down in activity. In the North the annual holiday is over, but the Midlands call a halt for what is known as "August week," consumption and production both being suspended in the majority of the factories during this period. From every point of view, both personal and mechanical, it is obvious that a break in the continuity of the year's work must be secured, for neither men nor machines can give of their best unless a periodic halt is called. Let us remember, too, that in many industries this has been a very busy year, and looking forward, we can see no indication of any let-up in activity, the metal industry, in particular, being thereby involved and pointing to a continuation of the high rate of consumption of copper, lead, spelter, aluminium, etc. In view of the urgency of rearmament it is not surprising that the call for these commodities is so well maintained, but what perhaps is not so clear is the failure of the quotations to respond to the insistent demand, bearing in mind, too, that it is not only in Britain that usage is on a big scale.

Actually the first six months, and indeed July also, have proved to be a period of marked stability in values, for fluctuations have been small, at any rate in copper, lead and spelter, while aluminium, of course, sells at a fixed price and there are no dealings in futures as we have in the others. Statistically the position of the four metals quoted on 'Change has been improving of late, although in the case of tin it only happens because the Pool is holding a large tonnage off the market; we must remember, too, that production of the others is wholly or partially controlled, the position in copper being that extra-American output is scaled down to 95 per cent. Output of lead is understood to be cut by 10 per cent., but just what the basis of this cut is it is hard to say, and, as for spelter, there has been plenty of talk about a cartel being formed since the duty was increased to 30s., but nothing has been done, and probably nothing will be, for there are many difficulties in the way. However, there is nothing much amiss with the position anywhere, and there appears to be every reason to expect a rise in values, given a return of confidence on the part of the speculator, who for months past has shown little or no inclination to take a hand in the game. It is, as a matter of fact, surprising that prices have not advanced, in view of the excellent rate of consumption, but somehow or other this buying by consumers does not get reflected on the Metal Exchange itself.

What is the speculator waiting for? As already mentioned, the statistical position of the base metals is favourable, at any rate, from the point of view of those who wish to operate on the bull trade, and so far as copper is concerned the idea is that for the next three to four months there will be a steady reduction in world stocks of this metal. This surely ought to put copper higher, and the speculator probably feels that the price will advance whatever happens, but he does not feel so sure whether, in the event of war breaking out, collection of the profits would be possible. Lead, too, is favoured for an appreciation in value, but latterly, a setback has come as soon as £15 was reached, and it looks as if the volume of hedge selling available at that level is more than enough to swamp buying, even though in that buying there is a good proportion of genuine trade demand. However, it does seem that on balance there is a real possibility of some appreciation in metal values during the autumn.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Cupola Control

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Referring to the correspondence from Dr. MacKenzie printed in your issue of June 29, I wish to thank him for the interest he has shown in my Paper. I cannot, however, agree with his remarks, as my assumption regarding the relationship of blast volume to coke is only reasonable. This fact may not be indicated by varying the blast, but it will by varying the coke ratio. His remark in connection with the variation in blast, "provided the bed has been adjusted to take care of it," suggests, in my opinion, a very unsatisfactory procedure. I consider the coke bed is difficult to regulate under constant working conditions without making alterations to suit a wide range of blast volumes. Reducing the blast may not be disastrous, although it will mean a waste of coke if favourable combustion is to be maintained; on the other hand, increasing the blast presents a problem to the cupola operator. It may not always be possible to foresee this alteration, so that additional coke may be added and the increase made at the precise time the extra coke reaches the bed.

Dr. MacKenzie gives us to understand that the only change taking place when the blast volume is varied is in the level of the coke bed. What of the velocity of the gases passing through the charge and the temperature of the escaping gases? I should think it would be necessary to vary the coke charge and accordingly the iron charge to suit the blast velocity, particularly when using a coke with a low rate of combustion.

I have found it good practice to standardise certain factors in the running of the cupola to maintain regularity and eliminate possible alterations. In this category is included the blast volume. Should it not be possible to take the metal from the cupola, then the blast is shut off. This procedure has been found to be very satisfactory.

I would like Dr. MacKenzie to appreciate that the deductions set forth in my Paper are primarily applicable to the balanced-blast cupola, in which the regulation of the blast volume is of considerable importance.—Yours, etc.,

H. P. HUGHES.

The Laboratory,
Grange Iron Works, Falkirk.
July 25, 1939.

Nickel Cast Iron in Chemical Plant

An evaporator body ring and inlet pipe made in nickel cast iron and installed in a chemical factory over eight years ago are still in good condition, whereas unalloyed cast-iron parts previously used had to be replaced every two years, because of erosion and corrosion. The composition of the nickel cast iron (given in "Nickel Bulletin") is: T.C, 3.00; Si, 1.50; Mn, 0.80, and Ni, 3.00 per cent., with 40 per cent. steel used in the mix. The main body ring which is 9 ft. 6 in. in diameter, has an average section thickness of 2 in. and weighs 8 tons. Although the unalloyed iron originally used eroded ½-in. per year, the nickel cast iron wears less than ⅛-in. Besides the improved wear-resistance secured by the addition of nickel, the grain refinement so produced aids machinability and increases pressure tightness.

he couldn't for the life of him think what it was. At last he drove into the yard of his own farm, where his daughter ran out to meet him.

"Oh, Feyther," she said, in an anxious voice. "Whatever have ye done with mother?"

"MARKSMAN."

Random Shots

After the death of the Engineers' Club many foundrymen transferred their affections (not to mention subscriptions) to the National Liberal Club. Now this club is beginning to feel the pinch and is appealing for 600 new members in order to swell its coffers. Could not the present "foundry" members do something about it and help to save yet another of the glories of old England from destruction? As it happens, the National Liberal Club has many claims to being ideal for members of the foundry industry. Firstly, its chairman, Sir Paul Booth, is a well-known foundry owner, and amongst many other personalities of the industry who figure in the membership list, is the president of the Institute of British Foundrymen, Mr. W. B. Lake himself. Then there is the building. The very nature of its interior decoration is calculated to make anyone who is familiar with the inside of a cupola feel thoroughly at home! Lastly, it is a liberal club in the truest sense in so much that members are admitted irrespective of politics.

* * *

Apropos of politics, the only two Cabinet Ministers who are leaving the country during the Parliamentary vacation are the Minister of Health and the Minister of Labour. In these days of dreadful uncertainty, it is a comforting thought that during August at least these two ministers can cheerfully hand over their responsibilities to the seaside landlady!

* * *

Incidentally a visit to any seaside resort with any pretensions to being a Spa is sufficient to explode the theory of the seven ages of man. There are only two which matter; the dotage and the don't age!

* * *

At one such resort, a visitor in the classiest boarding house was busy trying to acquire "tone." Turning to her dinner table neighbour, she asked, "And do you hunt?" To which the bored neighbour, who had more tone than he knew what to do with, replied, "Why, yes, I do, but only when I've lost something."

* * *

A notice recently seen on a suburban poster read as follows:—

"Come to our A.R.P. Fun Fair and enjoy yourselves."

No wonder foreigners find our English humour a shade difficult to understand!

* * *

Who says that committee meetings are dull? On the contrary, they are frequently the occasion of much mirth, providing as they sometimes do an opportunity for the quick-witted to shine, thus lightening the burden of others upon whom responsibility weighs heavily. A recent instance of this was at the last committee meeting of The Institute of Vitreous Enamellers, at which the following conversation was reported to have taken place (though not to have been entered in the minutes). Chairman: "How will September 1st suit you for the next meeting?" Mr. Gardom (facetiously): "Oh, no! That's my bath night." "Good," said Mr. Whittle. "That'll do fine. You'll have nothing on then."

* * *

The laugh having been so far mostly on the seaside, here is a charmingly simple story of a very rural farmer to finish with. He had been paying his regular, though far from frequent, visit to market. After having gone through carefully a long list of purchases, counting and recounting the parcels as they lay in the bottom of the trap, he set off for home. Nevertheless, as he went along he had a growing, uneasy feeling that he had forgotten something, though

(Continued in previous column.)

Organisation and Development of Steel Foundry Research*

By WILFRED JOHN DAWSON,† Assoc. Met., Sheffield

Introduction

The comprehensive character of this subject is such that a fully adequate treatment would require a contribution of much greater length than the present Paper. The subject has, therefore, been treated briefly in a number of sections, commencing with a somewhat historical treatment and concluding with a discussion of the outstanding problems. Prominence has been directed to the activities with which the author has been more particularly concerned, notably the work of the Steel Castings Research Committee of the Iron and Steel Institute.

There is probably no steel product which presents such difficulties in manufacture as a perfectly sound steel casting. It is true, also, to say that in few processes does successful production depend so much on the individual skill of the operative. Whilst the art of the moulder, accordingly, must always be an important factor in steel founding, the application of scientific control in the foundry plays an increasingly important rôle. In every branch of human activity this replacement of the art of the individual craftsmen by methods based on co-ordination of effort, and the systematised study of many experiences, is the natural course of progress.

When consideration is given to the accomplishments of the steel founders in the seventies of last century, it is impossible not to admire the excellent results obtained in the absence of all those methods of scientific control that are freely available to-day. Nevertheless, due to the absence of systematic knowledge, progress had doubtless to be paid for dearly in terms of wasters before a particular type of casting could be perfected. The history probably will never be written of those early struggles in the development of a technique which formed the basis of present practice.

EARLY DEVELOPMENTS

It was in the early fifties of the last century that success was first attained in making steel castings. Jakob Mayer, of Bochum, had overcome the disability arising from the burning-on of ordinary moulding sand to the casting by the use of calcined fireclay, or old crucibles ground to powder. The process was patented in England by E. Reipe, and first operated in this country by Vickers in 1855. The earlier castings made were bells, cog wheels, railway crossings and rings for rolling into railway tyres.[1]

The Terre Noire Works in France were supplying railway carriage wheels, crossings and rolls in 1870, and the author's own company, then known as the Hadfield Steel Foundry Company, exhibited at the Paris Exhibition of 1878, double spur wheels, railway crossings, wheels, pulleys and hydraulic cylinders.

It was only four years after this time that Mr. Hadfield, now Sir Robert Hadfield, Bt., F.R.S., invented manganese steel, and the subsequent application of this material in the production of manganese steel castings provided a signal instance of the value of research in the foundry. Concerning the origin of the first manganese steel castings, it may be of interest to recall that Hadfield, at that time a young man of 22, recorded in his experimental notebook under the date September 7, 1882, the following:—

> "I was led to make the following experiments with a view to the production of a very hard steel for tramway wheels, and grinding wheels or discs to be used in the place of emery wheels. The experiments have led to some curious, perhaps most momentous results that may to some extent *entirely revolutionise metallurgical opinions as regards alloys of iron and steel.*"

How true were the words italicised was amply proved by subsequent metallurgical history.

The perfecting of this first austenitic alloy steel as applied to castings involved the solution of new problems in every branch of manufacture: in modification of the material used in the ladle lining and of the refractories used in the moulding; new problems of feeding were involved and, owing to the hardness of the steel, new methods of cleaning, fettling and finishing had to be found; moreover, to develop the unique physical properties which characterised the new steel, the method of heat-treatment as used for ordinary steel castings had to be revolutionised.

Initiation of Sand Research

The application of scientific control in the metallurgy of steelmaking has been operative for many years; on the other hand, it is only within comparatively recent times that really serious attention has been devoted to scientific method in moulding and casting technique. Control of moulding sands is at the very foundation of steel-foundry technique. In this field, great credit must be given to Professor P. G. H. Boswell, amongst others, for his pioneer work, for it can be truly said that it was he who, in Great Britain, laid the foundation of the scientific testing of foundry sands.

Boswell himself in 1921[2] had noted that, although the extensive endowment of scientific research in the United States had become proverbial, it was remarkable that research upon foundry problems had there received so little attention. The Bureau of Standards alone had conducted investigations on moulding sands. Boswell had quoted the opinion of an authoritative American writer familiar with foundry technique that at that time, in Great Britain, he had found a more advanced state of affairs relating to the treatment and investigation of moulding sands. Boswell's conclusions resulting from his early inquiries were that in no branch of refractories were the results of research and tests under standard conditions more necessary.

In 1919 the Hadfield Company decided to intensify the study of foundry materials, and embarked upon a programme of investigation in consultation and co-operation with Professor Boswell. Organised work of this nature was still in its infancy, but a comprehensive scheme was worked out which had the following features:—The development of methods of testing for grading by elutriation, mechanical properties (crushing and transverse strength), permeability, as well as the accepted methods of chemical analysis; their application to the study of the materials in use and the alternative mixtures utilising artificial colloidal and other organic bonds; the correlation of the relationships determined with the behaviour of the sand in the mould, and with the character of the resultant casting.

The methods of testing were developed independently, but they had many points of resemblance to those ultimately agreed to by the American and British organisations studying the subject. Differences naturally occurred, and in these circumstances standardisation has ultimately been applied on the basis of the more widely practised methods, even though the earlier methods had some advantages in detail over their successors.

Since the inception of this scheme, the scientific control of moulding materials has been enlarged in scope and become more fruitful in its application. The development of metallurgical practice has introduced a new technique in melting and a multiplication of the types of steel to be encountered in casting. Machine-moulding has increased. All these changing conditions have introduced special moulding conditions involving specific foundry problems. Correlation of the results of laboratory tests with foundry experience has indicated the characteristics of major importance, so that it has become possible to forecast with reasonable certainty the behaviour of any sand mixture before being sent into the foundry. The value of such testing in the routine control of moulding sand needs no advocacy here. Many specific problems requiring new methods of investigation have been solved from time to time. A few examples out of many will serve as an illustration. Thus, in order to determine the conditions under which cores could be made to give in the baked condition the same size as the original core box, an investigation of the expansion characteristics was necessary, and ultimately the solution was found in the selection of a specific type of grading of the sand.

The use of old crucible pots and waste firebricks had certain disadvantages. They were growing scarce, or were variable in moulding compositions and uncertain in character. Investigations to find substitutes showed that there could be used a fired grog of a specific refractoriness, hardness and toughness, and that, with care in drying, a reducing atmosphere in burning and the presence of carbon being advantageous, the proper combination of different classes of clay could in the case of a manufactured grog give a material of the required character, if the economic factors were satisfactory.

The development of new paints, the establishment of the optimum conditions for tarring or coating moulds, the search for improved bonding by the use of deflocculating agents and organic binders and the determination of the bearing of the type of mill and its influence on the character of the product, are but a few of the many problems which have been investigated.

Pioneer American Investigations

Organised research on the properties of moulding sands, sponsored by the American Foundrymen's Association, began in 1921, at a time when little attention in that country had been given to sand control. Dr. Richard Moldenke, then secretary of the Association, had published the results of tests on a wide variety of sands carried out under his supervision. Moldenke's work had been in its earliest application concerned with the iron foundry, but his work showed a pioneer spirit and ultimately embraced all branches of the founder's art. His name, therefore, must be prominently associated with the early developments of scientific research in the foundry industry in America.

The American Foundrymen's Association, with the co-operation of the Division of Engineering, National Research Council, organised the Joint Committee on Moulding Sands Research to conduct "research on natural and synthetic moulding sands, as well as on the employment of greater proportions of used sands in moulding operations."

The primary need was considered to be the provision of practical and accurate methods for test-

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

† Hadfields, Limited, Sheffield.

ing the physical properties of foundry sands, and the properties decided to be of greatest importance were moisture content, permeability, strength, fineness, refractoriness and durability.

Tentative standards for the determination of these physical properties and methods for chemical analysis were published in 1924 by the Committee on Standard Tests. These were revised and elaborated, and a grading classification added, in 1928. Reference to this important work would not be complete without mention of the name of Dietert, whose pioneer work in connection with the development of sand testing appliances is well known.

The extensive nature of the American activities is indicated by the fact that, in the Steel Division of the American Foundrymen's Association, there are 32 Committees and Sub-Committees, of which no fewer than 13 are dealing specially with foundry sand research.

EDUCATIONAL FACILITIES

In the initiation and application of research a factor of cardinal importance is the provision of adequate educational facilities for training purposes. Not only does this apply to those who will ultimately serve as managers and foremen, but in some measure also to operatives. In order that the results of research shall be usefully applied in practice, it is of supreme importance that foundry personnel shall be so equipped in a scientific sense that they may be able to understand, translate and apply in practice the findings of the scientific workers.

That any doubt should ever arise that such a requirement is an essential feature of a progressive state of affairs in the industry is not to be expected. Nevertheless, the matter was raised in the United States in 1930, when the question was being considered of the modernisation of the existing shop for foundry work used in connection with the training of engineers at the Pennsylvania State College. Doubt was expressed as to whether the building and equipping of a new foundry was justified, since there was occurring at that time a tendency towards gradual displacement of castings in engineering practice by forgings and fabricated structures.[4] In answer to this challenge strong refutation of the doubt was expressed by the leaders of the foundry industry in that country, for obvious reasons, but it was also urged that the relative position of the various types of steel manufacture was subject to variation, that the pendulum had swung too far in favour of the competitive products, and that it would inevitably swing back and that the state of education and research in relation to the industry must be an index of that development.

At about the same time as the very existence of special foundry education was being challenged in the United States, Ingall,[5] on behalf of the Constantine Technical College of Middlesbrough, which now has a department for instruction in foundry work, had made an inquiry into the facilities for training foundry personnel in this country. The replies revealed that in many centres suitable courses were available, but there was a general lament that the number of students coming forward and (what is more important) the number completing the course were disappointing, and that the standard of education of the entrants was in many cases low.

During recent years the improvement of the education of foundry personnel has received considerable impetus both here and abroad. In France, the Ecole Supérieure de Fonderie, Paris, has been in existence for about 15 years and is claimed to be the first educational establishment of its kind. It specialises in higher education for foundry work. Courses in foundry instruction are also given at the Conservatoire des Arts et Métiers and at the Ecole Centrale des Arts et Manufactures. In addition there are available courses for apprentices at provincial centres, and those which form part of a works' organisation for the training of their own men.

The Technical High School, comprising also a Foundry Institute, at Aachen, is well known for the educational facilities provided for those in the foundry. A foundry course is included in the curriculum of the Clausthal Bergakademie, and foundry work is covered, although to a less extent, by the Freiberg Bergakademie. There are educational establishents dealing with foundry practice in Warsaw and Krakow.

Some dozen establishments of advanced rank in the United States carry out training and research in foundry practice. In a number of these, foundry conferences are held.

British Conditions

Dealing now with the United Kingdom, the industry is fortunate in having at Sheffield University, due largely to the enthusiastic pioneer work of Prof. J. H. Andrew, Dean of the Faculty of Metallurgy, what is probably the most complete equipment for the teaching and practice of foundry science available anywhere. The facilities include all the plant necessary for the production of steel castings on a practical scale from start to finish. A degree course in Foundry Science is provided in the Faculty of Metallurgy. In addition, the University provides exceptional facilities for the educating of foundry operatives in the form of trade lectures on foundry subjects.

This course, extending over three evening sessions, comprises training in metallurgy and the principles of foundry practice. Instruction is also provided for patternmakers and moulders. The influence of such a centre in inculcating a scientific spirit into the industry will be apparent.

Educational facilities in foundry work are provided by the British Foundry School, the foundation of which is largely due to the efforts of Mr. J. G. Pearce, the energetic and capable director of the British Cast Iron Research Association, and it is conducted in Birmingham under the ægis of that body.

Apart from the teaching institutions, the important influence exerted by the technical press ought not to be overlooked. The industry owes a debt of gratitude both to the foreign and British foundry Press; for example, the "Foundry Trade Journal," amongst others, renders excellent service, not only in publishing work done in this country, but by reviewing the major researches published abroad.

RESEARCH ACTIVITIES

Proceeding now to current activities of research organisations abroad and in this country, according to Mr. J. Léonard, Belgium is more individualistic with respect to technical and scientific investigations than other countries, and has no research association comparable with the British. The steel foundries in that country strive, each according to its means, to keep abreast of the requirements of the present time, the greatest advancement being made in the sphere of special alloys.

The Association Technique de Fonderie de Belgique has been active in the prosecution of research into sands and other foundry subjects, and Prof. A. Portevin has paid a high tribute to the activities of this body.[6] The Fonds National de Recherches Belge has also carried out researches on castability and on heat- and corrosion-resisting steel castings.

In France there is a special organisation concerned with the problems of steel casting, the Steel Casting Committee of the Association Technique de Fonderie, presided over by Mr. R. Lemoine. Problems are investigated by the research departments of the large French steelworks (Ugine, Imphy, Le Creusot, Firminy, St. Chamond, etc.), but it is understood that such research is not generally reported.

So far as Germany is concerned, Dr. Geilenkirchen, of the Technische Hauptausschuss für Giessereiwesen, has informed the author that the investigation of steel castings is not so highly organised in Germany as it is in England. On the other hand, private firms, especially the large companies, carry out extensive investigations in this field. The smaller companies also possess well-equipped laboratories and research departments. The Kaiser-Wilhelm Institute in Düsseldorf investigates technical foundry matters, but not to any special degree.

The Verein Deutscher Giessereifachleute, in which all branches of the foundry industry are represented, has formed a special steel castings committee, which co-ordinates the work of the separate private companies.

The Technical High School at Aachen is noted for its special research activities in connection with foundry problems, investigations being undertaken under the direction of Prof. Dr.-Ing. E. Piwowarski.

Research in foundry work is also carried out at Breslau Technical High School, at Berlin, at the Bergakademie Clausthal, and at Freiberg Bergakademie, where the work is concerned only with casting.

In Poland, steel foundry research occupies the attention of some half a dozen steelworks. A Polish Society of Foundrymen was founded in 1936.

In the United States of America, as in other countries, a large amount of research is carried out by individual firms, and the American Foundrymen's Association, as part of the programme of their general Foundry Sand Research Committee, is conducting at Cornell University some research on the effects of high temperature on steel foundry sands. In these respects probably the Battelle Memorial Institute is most prominent, and this famous metallurgical centre is excellently equipped to carry on research in steel foundry problems.

Steel-foundry research, in common with other research at Battelle, is concerned largely with work sponsored by industry. In some cases the sponsors are individual companies and in other cases associations. In either case, the problems are, in general, prescribed by the sponsor. The work is done on an actual cost basis, Battelle Institute being a non-profit organisation.

Other work is carried out on endowed funds of the Institute. Such investigations incline toward fundamental data of general application. Recent examples of these are a study of hydrogen in cast steel, the development of a simple and practicable test for the castability of steel, and a valuable research[7] on the effect of additions of aluminium used as a deoxidiser to steel on resultant ductility of the casting.

Thus, it will be seen that foundry training and research are being pursued in many countries. No doubt a certain amount of overlapping of work takes place, although this should not necessarily be considered a disadvantage; however, it would seem desirable that the research bodies should systematically inform their fellow workers in other countries of the nature of the work being instituted; such knowledge would undoubtedly be advantageous to those concerned in the planning of research programmes.

(To be continued.)

REFERENCES.

1 "Engineering," October 1, 1897, p. 403.
2 "Metallurgy and its Influence on Modern Progress," Sir Robert A. Hadfield, Bt., F.R.S., 1925, p. 74.
3 "British and American Foundry Practice, with Special Reference to the Use of Refractory Sands." P. G. H. Boswell. Univ. Press (Liverpool), Ltd., 1922.
4 "The Foundry," Vol. 58 (1930), p. 80.
5 "Foundry Trade Journal," Vol. 42 (1930), p. 451, and Vol. 43 (1930), p. 11.
6 *Bull. de l'Association Technique de Fonderie.* Vol. 11, February, 1937.
7 "Effect of Aluminium on the Properties of Medium Carbon Cast Steels"; C. E. Sims and B. Dahle. Trans. A.F.A., 1938, Vol. 46, Sept., pp. 65–103.

Thos. W. Ward, Limited, of Sheffield, have been appointed the sole selling agents for Great Britain for the specialities of Officina Meccanica Olivetti. The precision machines manufactured by the company referred to include bench and pillar drills, multi-spindle drillers and milling machines.

British Foundry School

ANNUAL MEETING AT BIRMINGHAM

The fourth annual meeting of the British Foundry School was held in Birmingham on July 25, Mr. R. G. Hosking (chairman) presiding. At the commencement of the proceedings reference was made by the chairman to the loss the School had sustained by the death of Mr. John Belliss. In his experience Mr. John Belliss was unique in one respect, for, said Mr. Hosking, he never knew him to be asked to do a single thing for the School which he not only undertook, but undertook readily and without the slightest hesitation.

Referring to the fact that the Foundry Technical Group of past and present students continued to grow in numbers and activity, Mr. Hosking said he was glad to learn that the positions held by old students continued to be just what they desired. Each year that passed showed that the influence they were having in the foundry industry and the outside world was progressively good. Students present that afternoon would in the course of time become past students, and he hoped they would take full advantage of the refresher courses which were held. Reference was made in the Report to the proposal of the Worshipful Company of Founders to award a fellowship of £250 per annum to men with certain qualifications. The first of those fellowships had still to be granted, and it was a matter for congratulation that they had been informed on good authority that it was likely to be offered to a past student of the School.

MR. F. J. COOK briefly seconded the adoption of the annual report and accounts, which was carried unanimously.

The Governing Body was re-elected *en bloc*, and the auditors were reappointed.

The chairman then invited Mr. J. G. Pearce, M.Sc., M.I.M.E., M.I.E.E., F.Inst.P. (Birmingham), who is Honorary Adviser to the School, to give a brief review of the visit by students to Sweden.

Visit to Sweden

MR. PEARCE remarked that they had only arrived back from Sweden the previous day. Such visits served two purposes. They were anxious to make a foreign visit each year, because foundry practice abroad was essentially different from what it was here. Secondly, such tours were educational, bringing the students into intimate contact with foreign countries. During the tour the party covered 1,100 miles and saw ten plants in seven working days. An endeavour was made to arrange a visit to every type of foundry, and they were successful in so doing with the possible exception of an up-to-date aluminium foundry. Everyone had been very hospitable to them. At Stockholm they were entertained to luncheon by the Swedish Engineering Manufacturers' Association, and hospitality was extended to them by four or five other companies.

Summarising his conclusions of the tour, Mr. Pearce referred to the absence of female labour in general. The men seemed to work much on British lines, but he gained the impression that they worked somewhat slower than foundrymen in this country. That applied to both hand and machine foundries. While the wages seemed to be somewhat lower, so was the cost of living, but the standard of living was a little higher than it was here. Swedish ironfounders were handicapped by the fact that, in the main, they had to import their pig-iron and coke, while they had no natural moulding sand. Naturally, that affected their technique considerably. In spite of those handicaps, they managed to compete in the international market.

Mr. Pearce thought the students who took part in the Swedish tour would agree that the heads of the various foundries were an extraordinarily fine type of men. They were well educated, well spoken, and technically minded. On the whole, he did not think that the Swedish foundries were any better equipped than foundries at home.

ANNUAL REPORT

The following information is extracted from the Annual Report:—

The fifth session of the School will open on September 19, and applications can now be received.

Twelve students were enrolled for the fourth session. About one-seventh of the students admitted have had public-school education, and a similar proportion have university degrees. The average age is about 24. The Foundry Technical Group of past and present students continues to grow in numbers and activity and holds regular meetings. For the first time, past students are to be found on the list of visiting specialist lecturers.

Mr. J. Bamford, B.Sc., continues as Lecturer-in-Charge of the School, with Mr. J. V. Chatterton as demonstrator, while Mr. W. E. Thorneycroft, B.Sc., of the staff of the Birmingham Central Technical College, has been responsible for metallurgical analysis, and Mr. A. A. Timmins, A.I.C., of the staff of the British Cast Iron Research Association, for pyrometry.

The curriculum covers a period of about forty working weeks of over thirty-nine hours per week, in addition to calling on a considerable amount of the student's own time. The essential basis of the School has been maintained; practical foundry training is not given, since adequate practical training is a requirement for admission. Considerable practical work, however, is done in the laboratories and in the foundry, in order to illustrate the work of the course. Considerable time continues to be given to practical studies in moulding and casting, involving the preparation of complete schemes of foundry production, and in foundry planning.

Referring to the visit to Sweden (reviewed by Mr. Pearce above), the Report stated that visits would be made to the following famous Swedish foundries and works:—Norrahammars Bruk; Husqvarna Vapenfabriks Ab.; Ab. Svenska Kullagerfabriken; Ab. Bolinder-Munktell; Sandvikens Jernverks Ab.; Ab. Separators Gjuterier; Ab. Gotaverken; and A.S.E.A.

Diploma Examination

The diploma examination consisted of four subjects—foundry metallurgy (two Papers), foundry technology, foundry management, and two Papers on moulding and casting studies and foundry planning, ferrous and non-ferrous. The written Papers on metallurgy, technology and management are each of three hours' duration. The practical Papers allow nine hours for the non-ferrous and twelve hours for the ferrous work. The Papers set for the diploma examination will be available to those interested, at a small charge.

The following authorities have acted as assessors in the preparation and marking of the Papers:—

Foundry Metallurgy.—Professor D. Hanson, D.Sc. (University of Birmingham).

Foundry Management and Foundry Technology.—Mr. E. R. Briggs, M.I.Mech.E. (Rugby).

Cast-Iron Moulding and Casting Study.—Mr. F. J. Cook, M.I.Mech.E. (Birmingham).

Steel Moulding and Casting Study.—Dr. C. J. Dadswell (Sheffield).

Non-Ferrous Moulding and Casting Study.—Mr. J. A. Clavey (Manchester).

The Governing Body hope to arrange a refresher course for past students, teachers of foundry subjects, and for a limited number of others interested, to be held during the Easter vacation, 1940.

The Governing Body expresses its thanks to the Birmingham Education Authority and to the Principal of the Birmingham Central Technical College, Dr. D. S. Anderson, where the School is housed, for their continued assistance and consideration.

The continued growth and development of the industry, its importance in national defence, and the acute shortage of properly trained executives in the industry, confirm the Governing Body in their view of the value of the School to the industry, and they urge responsible firms in the industry to consider nominating suitable men to take the course, or, if such men are not available, to establish a scheme of apprenticeship which will attract men of proper calibre, the concluding years of which should be spent at the School. A suitable basis for such apprenticeship has been prepared. It must be emphasised that since the large majority of students are nominated by their employers, to whom they naturally return, students leaving the School are not normally available for other employment.

New Holman Depot

For many years Holman Brothers, Limited, of Camborne, Cornwall, the well-known pneumatic-plant specialists, have had their London stores and service depôt at Spenser Street, Westminster, but the ever-increasing demand for their products in London and the Southern Counties made it imperative to seek a new site. That chosen was on the Westway Factory Estate, the postal address being 14, Brunel Road, Acton, W.3.

NEW LONDON DEPÔT OF HOLMAN BROTHERS.

A new building has been erected which consists of main stores, test shop, offices, storekeeper's flat, and mess room for the staff. The stores portion has a floor area of approximately 4,000 sq. ft., and a comprehensive stock of compressors, pneumatic tools, etc., is being built up. Suitable bins are provided for storing spare parts to service machines at work in the area.

Equipment is installed for effecting repairs to customer's machines, and any appliances reconditioned at the depôt are thoroughly tested before being returned to their owners. Air for this purpose is supplied by an electrically-driven "T.13.S" two-stage compressor. At the side entrance of the stores is a 5-ton crane—for handling goods being received or despatched.

The ground floor of the front part of the building is divided into four offices, and above these is a self-contained flat. This is occupied by the resident storekeeper, who is available for urgent requests.

Common Sense with Sand and Binders

By RALPH WELBURY*

During the past few months, as evidenced by the number of Papers, articles and references made to the subject of sand and binders, the question of the experience and training of the foundryman is coming to the fore. Gradually the wild and woolly stories of the high-pressure salesman who corners his victim and describes how wonderful his merchandise is, and how easy it is to apply it and to obtain good, sound, cheap saleable castings, whether they be alloy or plain carbon steel, steel mix, grey iron or non-ferrous, are being replaced by good sound knowledge.

From the standpoint of the foundryman, it is essential that the work produced should be of high quality, for every rejected casting costs as much as the corresponding good one, yet on remelting has only scrap value plus the usual expressive remarks, and can be replaced in the open market only by a new one. The writer, having had many years of practical foundry experience in Germany, Switzerland, Belgium, England and the United States, cannot help but note the different methods of producing a good casting.

The qualifications desired in materials to be used in the production of sand moulds and cores are:—

(1) Absence of occluded gases that are given off when the metal is poured.

(2) Retention of its form and yet crushing or disintegrating at the contact surfaces as the metal sets so that this may contract without danger of rupture.

(3) Cell structure of a porous nature to permit the escape of moisture and gases.

(4) Sand mould must withstand the severe action of the molten metal.

The sand must have the above qualities to produce good sound clean castings. Alloy steel has an exceptionally high temperature when in a molten condition, and some of the castings must withstand a working pressure up to and over 6,000 lbs. per sq. in.[1] Thus it is a matter of great importance that no slight defects are present in the sand. Such defects may not appear until after the finished casting is inspected and is beyond repair.

As silica sand is chiefly used now, though during the writer's apprenticeship ground firebricks and fireclay crucibles were the order of the day and castings were produced therefrom weighing a few ounces to 40 tons, one must be sure that the grain size is maintained for one particular class of castings or group castings. There are various methods of judging moulding sands according to distribution of grain size, as is stated by Bultman.[2]

"Plaster of paris" and a filler are being used in the place of sand moulds for the casting of brass, bronze and phosphor bronze to eliminate all machining. The filler is used to give the material a porous cell structure. The castings in the rough state are within 0.001-in. limits, and bevel and spur wheels and pinions with keyways will assemble without any machining. This plaster of paris mixture is poured upon the pattern, vibrated, then dried at a temperature of about 700 deg. C., and cores of similar composition installed where required and the mould poured while still warm. This is accomplished by a continuous mould drying oven, increasing gradually to the high temperature, held for a limited period and then coming into the cooler zone of the oven afterwards. They are cored, closed and poured while hot, so that no moisture will be absorbed. The used mould material is reground and added to a batch of new material.

In Tables I and II the experiments and experience on record will give the foundryman sufficient practical data so that he can adapt a similar method for his own benefit and increase his output, without increasing the cost of manufacture.

The various binders already in stock were taken into account, and Table I will give all the necessary information in order to show the results of these items operated at an elevated temperature.

TABLE I.—*Influence of Baking Temperature on Bonding Materials.*

Material.	Wt. used.	105 deg. C. 1 hr.	182 deg. C. 1 hr.	982 deg. C. 1 hr.	1,160 deg. C. 1 hr.
		Per cent.	Per cent.	Per cent.	Per cent.
Silica flour	5 g.	0.04 loss	0.06 loss	0.20 loss	0.20 loss
Bentonite	5 g.	4.47 ,,	4.56 ,,	9.55 ,,	14.00 ,, (*a*)
Fireclay	5 g.	5.74 ,,	5.88 ,,	14.01 ,,	15.00 ,, (*b*)
Proprietary bond	5 g.	8.00 ,,	10.67 ,,	99.89 ,,	— (*c*)
Flour	3 g.	6.37 ,,	7.03 ,, (*d*)	99.83 ,,	— (*e*)
Wash material	5 g.	7.30 ,, (*f*)	7.71 ,, (*g*)	14.04 ,, (*h*)	15.00 ,, (*h*)
Moulding sand	5 g.	0.05 ,,	0.00	0.10 ,,	0.00 (*i*)
White core sand	5 g.	3.55 ,,	3.79 ,,	5.47 ,,	6.20 ,,
Black core sand, No. 1 ..	5 g.	5.14 ,,	5.38 ,,	6.44 ,,	7.00 ,, (*j*)
Black core sand, No. 2 ..	5 g.	6.32 ,,	7.58 ,,	8.20 ,,	

(*a*) Changed colour from dirty white to light yellow or dark buff, also adhered to one mass, readily broken up.
(*b*) Changed from grey to a light orange colour.
(*c*) Residue consists of small globules of glassy material with greenish colour.
(*d*) Changed from white to a yellowish colour. Tendency for grains to stick together, but no strength.
(*e*) Residue consists of a few globules of fused substance. One or two particles green colour while others are nearly white.
(*f*) Greyish colour, similar to natural colour.
(*g*) The same results as 105 deg. C.
(*h*) Grains bonded into one mass, rather difficult to break up. Dark buff colour.
(*i*) A chunk of moulding sand from a mould ready for pouring, silica washed and skin dried. An average good mould broken for sample.
(*j*) Changed from black to orange colour. Small lumps easily broken.

Range of Temperatures

A temperature of 105 deg. C was used to drive off the moisture; 182 deg. C. is the lowest temperature of a badly operated core oven; 982 and 1,160 deg. C. are standard temperatures in several of the industrial muffle furnaces for current foundry production.

The results of the bonding material and the sand after all samples had been dried at 105 deg. C. and added to a 25 grams sample 1 c.c. of water (approximately 4.0 per cent.) are shown in Table II. All the materials were difficult to mix, as in water they became lumpy.

As will be noted by Tables I and II, the amount of organic matter that must pass off during the pouring of green and skin-dried moulds gives the required data as to the changes made when the sand is to be reworked. The results of Table I are very stable and can be used for the required sand mixtures. Silica flour, bentonite and fireclay materials that give the least organic matter and at the same time retain their bonding agents are the best to use.

TABLE II.—*Influence of Baking Temperature on Bonding Materials after Wetting.*

Material.	Wt. used.	105 deg. C. 1 hr.	182 deg. C. 1 hr.	982 deg. C. 1 hr.	1,160 deg. C. 1 hr.
		Per cent.	Per cent.	Per cent.	Per cent.
Silica flour	5 g.	3.01 loss	2.91 loss	3.30 loss	3.92 loss
Bentonite	5 g.	2.71 ,,	2.97 ,,	8.62 ,,	12.60 ,,
Fireclay	5 g.	3.35 ,,	3.69 ,,	11.69 ,,	12.20 ,,
Proprietary bond	5 g.	3.04 ,,	4.94 ,,	99.84 ,,	—
Flow	3 g.	7.83 ,, *	11.15 ,, *	99.80 ,, *	—
Silica sand	5 g.	3.46 ,,	3.70 ,,	5.43 ,,	6.00 ,,
White core sand	5 g.	5.40 ,,	5.26 ,,	6.45 ,,	7.00 ,,
Black core sand No. 1 ..	5 g.	5.88 ,,	6.05 ,,	7.38 ,,	7.70 ,,

* Flour shows that the addition of 4 per cent. moisture forms some reaction to the original substance and liberates a large volume of organic matter.

A batch of moulding sand was mixed to be used for facing, eliminating the materials having the most organic matter. The time to mull was determined by the sand mills in the laboratory and the foundry. Excellent results were obtained with the foundry mixture, and "let well enough alone" was the order. However, the results of the laboratory (Table III) were very interesting, as one of the facing mixtures (green-sand facing for snap flasks) took 5 to 7 min. to mull, and the tests showed gave 100 per cent. good results in producing castings:—Moisture, 3.60 per cent.; permeability, 220; length, $2\frac{1}{16}$ in.; green-sand strength, 7.8; weight, 160 g.

Other tests were made which resulted in eliminating dry-sand moulds for skin-dried moulds and castings up to $3\frac{1}{2}$ tons were poured. In all cases the silica wash was mixed with proper proportions and a given density of 53 to 55 deg. Baumé was made standard. This was sprayed upon the moulds while green, whilst cores were also sprayed green. In cases where heavy sections of metal (over 4 in. thick) were located, the cores and mould were washed again.

TABLE III.—*Influence of Mulling Time in Properties of Facing Sand.*

Mulling time.	Moisture. Per cent.	Permeability.	Length. In.	Green sand strengt .	Weight of sample. Grs.
2 ..	3.5	215	$2\frac{1}{16}$	7.1	160
3 ..	3.4	240	$2\frac{1}{16}$	7.0	160
4* ..	3.4	245	$2\frac{1}{16}$	7.9	160
5 ..	3.4	250	$2\frac{1}{16}$	7.5	160
10 ..	2.9	210	$2\frac{1}{16}$	6.6	160

* It showed that 3 to 5 min. periods would be correct time for the laboratory mixer and results agree very closely to the actual foundry practice.

These practical tests of binders for moulding sand and cores were for alloy steel castings for heat-resisting and oil well and field equipment (tubing and casing heads); the results were well justified by the cleaning room costs, and there alone was an approximate reduction of some 30 per cent. without any extra cost in production or equipment, thus showing what can be done with a little common sense and foundry experience.

* Metallurgist and Foundry Engineer, Philadelphia.
1 W. F. Chisholm. "Fight with an Oil Well." "Engineer," November 11, 1938.

2 "Giesserei Zeitung." June 21, 1935. Vol. 22.

The Open-Hearth Furnace for Melting Malleable Cast Iron

NOTES ON THE DESIGN AND OPERATION

By G. R. SHOTTON

(*Continued from page 59.*)

Gas Producer

The success of the open-hearth furnace will obviously be dependent to a great extent on the supply of a consistently good quality of producer gas. It is not proposed to deal with producer design in detail, since there are many different types of gas producer available, and the choice of a particular type of producer will depend on a number of purely domestic factors.

The fixed-bottom producer with a hand-operated charging hopper is the simplest form of producer, and is capable of yielding an excellent quality gas. Very close supervision is necessary with this type, however, since neglect by the operators can result in poor-quality gas and excessively high coal consumption.

The gas producer used to supply gas for the 15-ton furnace under consideration is of a mechanical type. The grate can be rotated slowly by mechanical power, and has ploughs fixed in such a manner that the ash is ploughed from the bottom of the ash bed as the grate rotates. The grate makes one complete revolution in two hours, but even at this slow speed it is only operated intermittently. The tuyeres, which are fixed to the grate and rotate with it, are designed so that the coal bed is alternately raised and lowered as the grate rotates, the undulating motion thus imparted to the coal bed being very effective as a means of keeping the coal bed in an open condition, and so preventing free air and carbon dioxide formed at the tuyere zone from "blowing through" near the walls of the producer.

TABLE I.—*Power Cost.*

Rate of current consumption.

Motor.	Current rating.	Power used. Kw. per hr.
Coal feed and distributor	440 volts × 1 amp.	½
Coal elevator to staging	440 volts × 1½ amp.	⅔
Rotation of bottom pan	440 volts × 1¾ amp.	¾

Daily consumption.

Motor.	Hours operating daily.	Daily power consumption. Units.	Total daily power cost at 1d. per kw. per hr.
Coal feed and distributor	22	½ × 22 = 11	16 units at 1d. per unit = 1s. 4d. per day.
Coal elevator to staging	3	⅔ × 3 = 2	
Rotation of pan ..	4	¾ × 4 = 3	

Some hand poking is also necessary from the top of the producer to prevent the coal caking at the distillation zone high up in the coal bed, but the amount of such poking necessary is greatly reduced by the agitation induced in the coal bed by the rotary movement of the grate and tuyeres. The efficient agitation of the coal bed is one of the most essential factors in producer practice if a high-quality gas is to be delivered to the melting furnace.

The coal feed is automatic, and can be regulated to give any required feed between 1 cwt. and 12 cwts. of coal per hr. The coal is fed from a small storage hopper by means of a screw feed, which delivers the coal into a small cone at the top of the producer, the coal falling from this cone being deflected by a slowly rotating shoe just beneath the cone, so that it is uniformly distributed over the whole area of the producer.

The current consumption of the motor driving the coal feed mechanism is about 0.50 kw. per hr., and is running for 20 to 22 hrs. every day. The grate is rotated by a 2-h.p. motor, absorbing approximately 0.75 kw. per hr., but this is only operating for about 4 hrs. per day, the period of operation varying from 15 to 30 min.

The air supply is induced into the intake pipe leading to the tuyeres by means of a steam injector, the steam supply being obtained from a small cross-tube boiler, which also provides the steam for another gas producer feeding the annealing plant.

The control of the steam and air mixture in the intake pipe is highly important, as too low a proportion of steam in the mixture will result in the formation of a heavy clinker, while an excess of steam will reduce the temperature of the lower zone and result in an unduly high proportion of CO_2 in the gas obtained.

The steam pressure is kept constant by means of a balancing valve in the steam supply pipe, so that the amount of steam passing through the injector depends entirely on the aperture at which the injector is set, and is thus capable of fairly close regulation. The pressure of the steam and air mixture in the tuyere box is measured on a gauge and is controlled by the regulation of the steam injector. This ensures reasonably consistent conditions in the gas producer, and a good quality of producer gas is maintained without difficulty.

The power consumption and cost, based on one penny per kilowatt hour for the electric current, are set out in Table I.

Assuming 11 charges averaging 10 tons are melted during the week, then the power cost per ton of metal melted is approximately 1.1d. per ton, while on charges averaging 8 tons each, the power cost would rise to 1.4d. per ton of metal melted.

Operation of the Furnace

Although a soaking flame is maintained in the furnace during the night and week-end periods, it is also necessary to preheat the furnace prior to charging.

During the soaking period, the air valve is practically closed, the stack damper is lowered to leave only about 1 in. of space open for the exhaust gases, and a coal feed of about 1¼ cwts. of coal per hr. is maintained on the gas producer. The gas producer is operated at a slow rate, the steam injector being regulated to maintain a very low pressure in the tuyere box. Under these conditions, just sufficient gas is being fed to the furnace to ensure that the body of the furnace is almost completely filled with a gentle rolling flame, thus ensuring that there is no serious drop in the temperature of the furnace body, nor in the temperature of the regenerator brickwork. About two hours before charging is due to commence, the coal feed is increased to 6 cwts. per hr., the air and stack dampers are opened, and a melting flame is maintained to raise the temperature of the furnace body and regenerators.

As soon as the furnacemen come on duty, they tap out any small accumulation of slag formed during the preheat period, and then fettle the bed. If any slag has remained on the furnace bed, it is removed by "puddling" it with wet silica sand, which is afterwards raked out through the working doors, any hollows or cracks remaining in the bed being afterwards filled up with dry silica sand, which is "fritted" on before charging is commenced.

The metal is then charged through the working doors. The foundry scrap, consisting of feeders, sprues, rejects, etc., is first charged, the bulk being charged on the middle of the bed, any steel scrap to be included being distributed amongst the foundry scrap to facilitate melting. The pig-iron is then "peeled" into the furnace, the bulk of it being placed at the ends of the furnace bed. It is usual to allow an interval of about 10 to 15 mins. after charging about two-thirds of the foundry scrap. While this prolongs the charging time, it is effective in speeding up the melting-down period by reducing the tendency of the molten metal trickling down to resolidify when it comes into contact with the cooler metal on the bed of the furnace.

During the melting-down period the coal feed is at its maximum, being usually at the rate of 6 to 7 cwts. per hr., and the steam injector is adjusted to give a higher pressure in the tuyere box to maintain standard conditions in the producer itself. After about one hour, molten metal will begin to accumulate on the bed of the furnace, and the furnaceman will then hasten the melting by breaking up masses of unmelted metal, and pulling it into the pools of molten metal on the bed. The correct manipulation of the charge at this stage is a big factor in obtaining rapid melting.

TABLE II.—*Daily Time Table for Two 10-ton Heats.*

Time.	Operation.	Coal feed.
4.0 a.m.	Commence preheat ..	6 to 7 cwts. per hr.
6.0 a.m.	Furnacemen come on duty. Slag tapped and furnace bed fettled	Feed stopped.
6.20 a.m.	Commence charging ..	6 cwts. per hr.
7.30 a.m.	Charging completed ..	7 cwts. per hr.
8.50 a.m.	Pools of molten metal collecting on bed. Furnaceman commences to manipulate unmelted material to hasten melting	Not altered.
9.55 a.m.	Charge completely molten	6 cwts. per hr.
10.10 a.m.	Test sample taken for analysis	Not altered.
10.55 a.m.	Laboratory report received	
11.00 a.m.	Tapping commenced. Air valve and stack damper closed slightly	5 cwts. per hr.
11.50 a.m.	Tapping completed and bed fettled	5 cwts. per hr.
12.15 p.m.	Commence charging second heat	6 cwts. per hr.
1.20 p.m.	Charging completed ..	7 cwts. per hr.
3.40 p.m.	Charge completely molten	6 cwts. per hr.
3.55 p.m.	Test sample taken for analysis	Not altered.
4.40 p.m.	Laboratory report received and metal tapped	5 cwts. per hr.
5.30 p.m.	Tapping completed ..	Feed stopped.
5.45 p.m.	Bath fettled	—
5.50 p.m.	Gas flues opened for cleaning	—
7.00 p.m.	Gas flues sealed. Air valve and stack damper closed sufficiently to maintain soaking flame in furnace	1¼ cwts. per hr.

A charge of 8 to 10 tons should be melted down in 1¾ to 2 hrs. after completion of charging. The charge should now be continually rabbled to raise the colder metal from the bed of the furnace and to help to melt the remaining pieces of solid metal floating in the bath. Under normal conditions, an 8-ton charge will be completely molten in about 2¼ hrs. after completion of charging, a 10-ton charge taking perhaps 20 mins. longer.

The furnaceman notes the time when the charge becomes completely molten, and con-

tinues to rabble the metal at frequent intervals to ensure that the charge is thoroughly mixed, and about 15 minutes after melting has been completed, when the metal charge is well mixed, a small sample of metal is ladled out and cast into a chill mould. This is quenched and drilled, and the drillings are hurried to the laboratory for the estimation of total carbon and silicon. About 45 minutes are absorbed by the quenching and drilling of the test sample and the subsequent analysis.

TABLE III.—*Coal Consumption for Soaking Periods and Swill Heats.*

Soaking.—	
Daily (Monday to Friday), 9 hours at 1¼ cwts. per hr.	12 cwts. daily for 5 days.
Ditto (Saturday), 14 hours at 1¼ cwts. per hr.	18 cwts.
Ditto (Sunday), 12 hours at 1¼ cwts. per hr.	15 cwts.
Total fuel used during soaking periods	93 cwts. per week.
Swill heat.—	
(Sunday), 8 hrs. firing at 6 cwts. per hr.	48 cwts. per week.
Total fuel used weekly apart from actual melting	141 cwts.

Note.—This coal consumption is fairly standard over each weekly period, and bears no relation to the capacity at which the furnace is worked.

While this is in progress, the furnaceman will continue to rabble the metal bath, which usually receives sufficient superheating during this period to enable tapping to commence immediately the analysis is approved by the laboratory. If adjustment of analysis is considered necessary, suitable additions are made to the bath, and after a thorough rabbling of the charge to ensure uniformity of analysis, the metal is tapped. As the metal is shanked from the furnace in 1-cwt. ladles, a small tapping hole is used. A 10-ton charge will normally be tapped in about 50 minutes, though this can be modified to suit the requirements of the foundry.

After the metal has all been tapped, the slag is drained from the furnace bed, and the latter is fettled as before. Charging of the next heat can then commence, after an interval of 10 to 20 minutes to "frit" on any sand added to the bed when fettling. Usually the second heat can be melted and tapped in 15 to 30 minutes less time than was occupied by the first heat. A typical daily timetable for two 10-ton heats would be as shown in Table II.

As instanced in the schedule set out in Table II, a 10-ton charge will normally take about 3½ hours from completion of charging to commencement of tapping. This is equivalent to about 5½ hours' total time, from commencement of charging to completion of tapping. No very great reduction in time is apparent with smaller charges, as an 8-ton heat occupies 5 to 5¼ hours overall, and a 6-ton heat takes 4¼ to 4¾ hours from commencement of charging to completion of tapping.

Melting Losses

Melting losses are very consistent, and little difficulty is experienced in tapping metal to the required analysis. The iron produced is a low total-carbon white iron suitable for the production of blackheart malleable cast iron. Most of the melting losses take place during the melting-down period, only a slight change in analysis being apparent during the superheating period.

The melting loss on total carbon is usually between 0.32 and 0.40 per cent., the required total carbon being of the order of 2.4 per cent. Except under certain abnormal conditions, the metal is usually tapped with a total carbon content within ± 0.05 per cent. of the desired figure.

The silicon content normally shows a melting loss of between 0.30 and 0.35 per cent., the required silicon content being about 1.0 per cent. The normal variation of silicon content in the metal tapped is within ± 0.03 per cent.

Occasionally the losses on total carbon and silicon will vary outside the above limits, but as this is detected when the test sample is analysed, the metal in the furnace can be corrected before tapping. Such abnormal variations in melting losses usually coincide with an appreciable change in the time occupied in melting down. Occasionally a charge is melted down in an appreciably shorter time than is usual, and the melting losses under such conditions are lower. Conversely, if the melting-down time is prolonged, greater oxidation of the charge will take place, and the losses on total carbon and silicon will be greater.

Provided that the quality of gas supplied to the furnace is maintained at the normal standard, the melting-down time for a given size of charge is fairly regular, and consecutive charges can be tapped within the limits of analysis given above.

Fuel Costs

The cost of both fuel and power will show a rather wide range of variation, when expressed in terms of cost per ton of metal melted. The fuel absorbed during the soaking periods, *i.e.* during the night and at week-ends, together with the fuel absorbed by the "swill-heat" at the week-end, will be relatively high when compared with the fuel used for actual melting.

The furnace is soaking for about 9 hrs. every day, during which period the coal feed is between 1.0 and 1.5 cwts. per hr. The same feed is used for the week-end period, with the exception of the "swill-heat" periods, which total between 6 and 10 hrs. in duration, during which time the coal feed is at the rate of 5 to 6 cwts. per hr. A simple calculation will thus show that approximately 140 cwts. of coal per week will be absorbed in addition to the coal used for the final preheating of the furnace and in melting the actual charges. This figure is confirmed by actual coal consumption figures obtained over a period. The coal consumed during soaking and "swill-heat" periods will, therefore, be fairly standard over any given period, independent of the tonnage of metal melted.

The coal consumed when melting the charge, including the coal utilised for the final preheat each morning, will vary according to the size of the charge melted, but will not be in strict proportion. It is thus apparent that if the furnace is worked at low capacity, the coal consumed in melting will show a slight increase when expressed in cwts. of coal per ton of metal melted, while the coal utilised for soaking, etc., will show a figure which, expressed in terms of consumption per ton of metal melted, will vary in inverse proportion to the tonnage of metal melted.

Fuel consumption figures are given in Tables III and IV for the operation of the furnace on 8-ton and on 10-ton heats. Unfortunately, no data are yet available for larger heats over a period, but a further reduction in fuel costs is certain to be experienced when regularly melting heats of 12 to 15 tons. The figures given are the calculated coal consumptions based on the rating of the automatic coal feed and the time taken on the various stages of melting. These figures can be taken as representing the average actual coal consumption, which naturally varies somewhat from heat to heat, but which is checked weekly by a comparison of the calculated consumption with the actual coal consumption over each weekly period.

If the furnace is being operated on charges averaging 8 tons each (*i.e.*, 88 tons per week), this will show a fuel consumption for soaking periods, etc., of 1.60 cwt. of coal per ton of metal melted. On the other hand, if the furnace is being operated on charges averaging 10 tons each (110 tons per week), the fuel consumption on soaking periods, etc., will only be at the rate of 1.28 cwt. per ton of metal melted, and there would be a corresponding reduction in consumption rates if still larger metal charges were regularly melted.

The total fuel consumption per ton of metal melted will be the sum of the fuel used on soaking and on actual melting.

For 110 tons per week this equals
1.28 plus 4.51
= 5.79 *cwts. per ton of metal melted.*

For 88 tons per week it is
1.60 plus 5.24
= 6.84 *cwts. per ton of metal melted.*

To the figures of Tables III and IV must be added the coal used on the boiler supplying steam to the gas producers. This boiler uses approximately 8 tons of coal per week, and supplies a duplicate gas producer also, which provides gas for the annealing plant. Half of this coal should be allocated to the melting furnace (*i.e.*, 4 tons per week), and this will raise the fuel consumption figure by 0.73 and 0.91 for 110 tons output and 88 tons output respectively.

Therefore the gross fuel consumption used on the entire melting plant will now be:—

On 110 *tons weekly output*
5.79 plus 0.73
= 6.52 *cwts. of coal per ton of metal melted.*

On 88 *tons weekly output*
6.84 plus 0.91
= 7.75 *cwts. of coal per ton of metal melted.*

These figures will bear comparison with any other type of melting furnace capable of operating on low total-carbon white iron. It is con-

TABLE IV.—*Fuel Consumption on Melting.*

Case (1).—Based on average charges of 10 tons each, *i.e.*, 110 tons of metal melted per week.

Preheat	2 hours at 7 cwts. per hour on 6 days	84 cwts. per week.
Melting	*Charging, etc.*, 1½ hours at 6 cwts. per hour on 11 heats	99 " " "
	Melting down, 2½ hours at 7 cwts. per hour on 11 heats	192 " " "
	Superheating, 1 hour at 6 cwts. per hour on 11 heats	66 " " "
	Tapping and fettling, 1 hour at 5 cwts. per hour on 11 heats	55 " " "
	Total fuel to melt 11 heats of 10 tons each	496 cwts.

This is equivalent to 4.51 cwts. of coal per ton of metal melted.

Case (2).—Based on average charges of 8 tons each, *i.e.*, 88 tons of metal melted per week.

Preheat	2 hours at 6 cwts. per hour on 6 days	72 cwts. per week.
Melting	*Charging, etc.*, 1½ hours at 6 cwts. per hour on 11 heats	99 " " "
	Melting down, 2¾ hours at 7 cwts. per hour on 11 heats	173 " " "
	Superheating, 1 hour at 6 cwts. per hour on 11 heats	66 " " "
	Tapping and fettling, ¾ hour at 5 cwts. per hour on 11 heats	51 " " "
	Total fuel to melt 11 heats of 8 tons each	461 cwts.

This is equivalent to 5.24 cwts. coal per ton of metal melted.

sidered probable that the fuel consumption may fall below 6 cwts. of coal per ton of metal melted if the furnace is operated continuously on larger heats of 12 to 15 tons each. As heats of over 10 tons have not yet been melted with any degree of regularity, this is, for the time, a matter of conjecture and cannot yet be checked over any lengthy period.

Total Operating Costs

The total cost of operating the open-hearth furnace will be the sum of the fuel cost, plus the power costs, plus cost of refractories and fluxes. These costs have all been itemised under their different headings and they are now assembled in Table V.

TABLE V.—*Total Melting Costs.*

Case (1).—10-ton charges (110 tons per week).

Gross fuel cost (including boiler), 6.52 cwts. at 21s. per ton	7s. 0d.	
Power costs on gas-producer plant	0s. 1.1d.	
Total cost of fuel and power	7s. 1.1d.	
Refractory and repairs	1s. 7.0d.	Estimated. See text.
Fluxes used for melting and swill heats	0s. 4.0d.	
Total melting and maintenance costs (excluding labour)	9s. 0.1d.	per ton of metal melted.

Case (2).—8-ton charges (88 tons per week).

Gross fuel cost (including boiler), 7.75 cwts. at 21s. per ton	8s. 1d.	
Power costs on gas-producer plant	0s. 1.4d.	
Total cost of fuel and power	8s. 2.4d.	
Refractories and repairs	1s. 11.0d.	Estimated. See text.
Fluxes used for melting and "swill heats"	0s. 4.5d.	
Total melting and maintenance costs (excluding labour)	10s. 5.9d.	per ton of metal melted.

Apart from affording a fairly close statement of operating costs on the open-hearth furnace, these figures also serve to emphasise the rather wide variation in melting costs dependent on the output from a particular furnace. The relatively high cost of the fuel used when the furnace is not actually melting metal, together with the cost of refractory materials used for maintenance and repairs, has a profound effect on melting costs when expressed in terms of cost per ton of metal melted.

Conclusion

In conclusion, the principal advantages and disadvantages of this furnace can be briefly summarised as follows:—

The high capital cost is a serious disadvantage, as in addition to the cost of the furnace itself, gas-producing plant also must be installed.

Since the furnace proper is constructed of silica bricks, it is necessary to maintain its temperature fairly near to melting temperature when not in operation. Violent fluctuations of temperature would result in spalling of the silica bricks and necessitate more frequent shut-downs for repairs. It is also important that the temperature of the regenerative chambers be maintained near working temperature. Therefore the amount of fuel absorbed in soaking periods is relatively high compared with the fuel used in actually melting the charge, and it thus follows that the total fuel cost may become uneconomically high if the furnace is operated well below capacity. If the furnace is operated at normal capacity, fuel costs are relatively low, as evidenced by the data given in the section dealing with melting costs.

The furnace can be operated continuously for long periods, and will, in fact, yield better results under such conditions. On the other hand, any major repairs which may become necessary will necessitate a complete shut-down for several days.

Since the supply of molten metal for the foundry is intermittent, it precludes the use of a fully-mechanised continuous moulding system. Under certain conditions this may be a disadvantage. On the other hand, it supplies a large bulk of metal (according to the furnace capacity) which is all of a uniform analysis.

It admits a close control of analysis. Melting losses are fairly constant, but when variations do occur, the analysis can be corrected before tapping the metal. In this respect, it is usual to take a bath sample of molten metal for analysis about 45 minutes before the charge is due to be tapped.

The molten metal can be superheated to suit foundry requirements by holding the charge in the furnace until the required temperature is reached. During this period the slag layer covering the metal will prevent any serious oxidation of the charge.

Close supervision and technical control are essential, owing to the somewhat complex nature of the open-hearth furnace and gas-producer plant.

It will be evident from the data given that the open-hearth furnace is a comparatively cheap melting unit when operated near maximum capacity, and might be considered an economical proposition even when operated down to about half capacity. On smaller outputs, however, the operating costs may quickly become prohibitive.

Catalogues Received

Refractories. J. H. Sankey & Son, Limited, of Ilford, Essex, have sent us a copy of their new catalogue on refractories. Its outstanding features are its completeness and its interesting method of presenting data. The various shapes available are illustrated with dimensions both in inches and millimetres. This useful information is reinforced by the inclusion of tables for constructing arches and circular linings, and formulæ for arch and radial bricks. Another useful section is that devoted to estimating the quantities of cement required for setting brickwork. A very well printed colour heat chart is included, but to-day, with wide variations in shop lighting conditions, associated with the general use of pyrometers, the reviewer doubts whether such empirical information is worth the cost of reproduction. The catalogue contains thirty well-illustrated pages, most of which contain carefully chosen information of direct use to foundrymen and those concerned with furnace construction and maintenance. The catalogue is available to our readers on writing to Ilford.

Temperature Regulators. A four-page leaflet received from the Cambridge Scientific Instrument Company, Limited, of 13, Grosvenor Place, London, S.W.1, describes and illustrates a line of apparatus for continuously recording and regulating temperatures up to 600 deg. C. The control temperature being set by an index pointer on a divided scale, a contact arm thereafter operates auxiliary mechanism by a make and break action.

Flames and Furnaces

INTERNATIONAL CONFERENCE PROJECTED

An International Conference on Flames and Furnaces will be held from September 17 to 20, 1940, at the Royal Institution in London. The Institute of Fuel has made itself responsible for convening the Conference, and the technical organisation has been undertaken by the British Coal Utilisation Research Association.

The progress in the scientific study of flame by the methods of chemical kinetics and spectroscopy is opening up new fields which have great engineering and industrial possibilities. One purpose of the Conference is to bring these new developments to the notice of engineers and industrialists with a view to accelerating their practical application. Modern industry is calling for higher performance from furnaces and this creates problems which can sometimes only be solved by fundamental research. The technical programme of the Conference has been prepared by a Committee of thirty engineers and scientists under the chairmanship of Mr. J. G. Bennett, the Director of the B.C.U.R.A., and constitutes a planned attack on the problem of flames and their industrial applications. Flames in the internal-combustion engine and explosive flames generally are excluded from the scope of the Conference, which will be concerned with the free combustion of gases, liquids and solids in air.

This field is, as a matter of fact, almost entirely unexplored; and the Conference should, therefore, result in the collection and dissemination of hitherto uncorrelated information of much interest and practical value to the gas, oil and coal industries.

The editorial committee proposes to organise the Conference on somewhat novel lines in that the authors of Papers will be invited to collaborate in covering the whole ground of flame and furnace research with the minimum of duplication and overlap. Selected authors throughout the world will be asked to contribute Papers on specified problems and early in 1940 the editorial committee will undertake the task of co-ordinating the various Papers into a homogeneous review of the subject. Selected experts in each field will examine the Papers, and act as chairmen and reporters of the various technical sessions.

Book Review

The Factories Act, 1937. By H. Samuels, M.A. Second edition. Published by Stevens & Sons, Limited, 119 and 120, Chancery Lane, London, W.C.2. Price £1 10s. net.

When the first edition appeared in the autumn of 1937, we deemed it to be of such importance that we devoted a long leading article to its contents. Therein its lucidity was commended, and the executives responsible for the application of the provisions of the Act were urged to read the book and master its contents.

The preface to the second edition states that many factory occupiers have not as yet fully acquainted themselves with the obligations which are imposed upon them by the far-reaching enactment which is the subject of this volume. Attention is drawn to, and notes are given upon, the new Regulations which have come into being since the last edition, but the time factor has precluded the inclusion of the additional obligations imposed by the provisions of the Civil Defence Act. The book can be regarded as a reliable textbook on the field covered. It is so well indexed that the layman will have no difficulty in finding the provisions of the law in which he is interested.

Core-Shop Control

WRITTEN CONTRIBUTIONS TO DISCUSSION

Mr. J. J. Sheehan's Paper to the International Foundry Congress in London has been productive of some interesting written discussion, and below we print comments from Mr. E. J. Crawley, Mr. A. J. Shore and Mr. W. Y. Buchanan, with the author's replies.

Fin Formation

MR. E. J. CRAWLEY wrote that he was most interested in the method described for overcoming the tendency of fin formation by the use of an irregularly graded sand mixture. He understood that a similar principle had also been adopted for preventing metal penetration in cores surrounded with heavy-section steel castings. In this case, however, the advantage obtained relied on reduced permeability.

Mr. Sheehan's explanation of the reason why this process reduced the tendency for fin formation appeared very likely. However, there was another factor which perhaps should be taken into consideration. A core composed of uniformly-sized sand grains depended almost wholly upon the bonding properties of the binder to give it strength. When this binder was partly or wholly destroyed, the core became so weak that slight stress (resulting from expansion) caused a tear, which had relation to a fin being formed. On the other hand, a core composed of sand grains of two sizes, particularly if one was very fine, was much more compact and consequently stronger, irrespective of the cohesion given by the binder. This factor might have bearing on the reduced tendency for the core to tear following an uneven expansion.

In support of Mr. Sheehan's explanation, it would be interesting to learn whether a core of uniform sand grains such as in No. 1 (Fig. 24) showed a steeper expansion curve when heated rapidly than did No. 3, composed of coarse and fine sand mixed.

Preventing Metal Penetration

MR. J. J. SHEEHAN wrote in reply that Mr. Crawley was correct in assuming that a mixture of sand grain sizes in a core was of advantage in preventing metal penetration. The advantage was obtained by a reduction in the void spaces. A reduced permeability in the core was a parallel effect and not the direct cause of the reduced penetration.

He was in agreement with Mr. Crawley's statements in the second paragraph of his communication, but did not accept the assumption that the difference in strength between the two types of core was sufficient to account for the absence of an expansion crack in the core with a mixture of grain sizes. He was certain that the force of expansion produced by a change from quartzite to cristobalite was of a much higher order than the frictional strength produced in a core by using a mixture of grain sizes.

He was not in a position further to confirm the explanation of the expansion effects, by the method suggested by Mr. Crawley, but he considered the method good and the confirmation a desirable one, and would welcome such confirmation from a laboratory equipped with an accurate extensometer and a suitable furnace.

Analogy with Professor Bragg's Lecture

In a written contribution, MR. A. J. SHORE stated that Mr. Sheehan's Paper could be considered as supplementary to Prof. Bragg's lecture delivered to the Congress. At first sight, there seemed to be little in common between such subjects as "Core Shop Control" and the "Atomic Pattern of Metals." However, scientific method was so powerful an instrument that both investigators uncovered similar facts. No one, for instance, could fail to appreciate the similarity between the body-centred and face-centred cubes in Prof. Bragg's atomic space-lattice and Mr. Sheehan's conditions of open and close packing of uniform grains of sand.

Prof. Bragg had shown how extraordinarily ductile and weak a single crystal of metal was, explaining that in this case the atoms were uniformly arranged in regular order. Mr. Sheehan also had experienced—very forcibly—the weakness of bodies regularly compacted of uniform particles. He mentioned the rather disastrous results produced in the fettling shop when an attempt was made to use a uniformly-grained core sand. His solution of the problem was the same as Prof. Bragg's; he made an "alloy" to increase the strength by adding other suitable grades of sand. In other words, he produced what the Professor had called "organised muddle." The ability to produce "organised muddle" as distinct from "muddle" was the essence of core-shop control, and for that matter, of any human activity.

In conclusion, Mr. Shore observed that Mr. Sheehan's Paper was of the type which was most likely to benefit the foundry industry, and that it formed that link between academic research on the one hand and commercial production on the other, which Prof. Bragg had said was so desirable.

A New Nomenclature

MR. SHEEHAN, in his reply, thought Mr. Shore's similes were very good. His appreciation of the usefulness of "sand alloys," and his coining of the phrase had induced him to consider another borrowed phrase, "eutectic," to describe the point where a mixture of sizes produced the greatest density and least length of the test-piece. Such a point was shown in Fig. 18 and in Fig. 19, and coincided in both figures with a proportion of about 66.6 per cent. of the larger grained sand. He did not, however, suggest that either of these metallurgical terms should be applied seriously.

Influence of Flowability

MR. W. Y. BUCHANAN wrote that he was specially interested in the reference to mixing of grains of different size, because that line of argument was at one time brought into the discussion on his suggested "Index of Ramming" method of test-piece ramming evaluation. As stated in his Paper* to the Sheffield Branch the argument does not apply. While the assumption of perfect packing in the case of spheres is possible in ideal circumstances—for example where they are packed a layer at a time—and also to some extent in unbonded sands. Such mathematical forecasts of the behaviour of natural bonded sands are completely masked by their low flowability.

The situation of small grains in any mass of sand is largely a matter of efficiency of mixing rather than ramming, but conclusions should be based on tests on natural sands (unless they are to be excluded) rammed by the standard three blows of a 14-lb. rammer.

The writer's own conclusion was:—

> "While the unmixed test-pieces are longer, it will be seen that hardness on the bottom of the test-piece is very low, and that the increase in length is due to the poor flowability and not to fine material becoming packed in air spaces of the coarse sand in the case of the mixed test-piece."

Mr. Sheehan used a specific heat for silica of 0.286 at 1,000 deg. C. and for graphite at 978 deg. C. What did these temperatures represent?

The writer had found that published details of specific heat and specific gravity of moulding materials, etc., at high temperatures were almost non-existent and rather vague, so that he had determined these properties himself, and he would have liked Mr. Sheehan to have extended the data available by personal research.

The testing machine for green-sand cores was evidently a form of compression test. What was its particular advantage over the existing spring balance?

Mr. Buchanan added that he had controlled his blackwash by tank mixing for the last five years by a system of specific gravity and constituent analysis as a check. He readily agreed with Mr. Sheehan that the viscometer would be far better than specific gravity measurement, because the specific gravity of blacking, for example, was very low, and its percentage could vary considerably without altering the specific gravity of the liquid blackwash. If this was not done elsewhere, could Mr. Sheehan publish dimensions of the particular viscometer used, as this could be adopted, if not by the Committee, at least by those interested in their own work.

Mr. Sheehan's Reply

In reply to Mr. Buchanan, MR. SHEEHAN pointed out that he could not contribute much to the first portion of Mr. Buchanan's observations, which dealt, not with the author's paper, but with one given by Mr. Buchanan to the Sheffield Branch of the Institute of British Foundrymen. In that Paper Mr. Buchanan did not give the mechanical analysis of any of the materials he used, nor did he produce any evidence such as the quantative relation between the flowability and hardness to show that his explanation was correct.

The tests mentioned in the author's Paper were carried out up to 500 blows, and if the difference shown was due to flowability the curves should get closer together as ramming was increased. This did not occur.

Mr. Buchanan had asked what the temperatures represented in the statement: "Specific heat of silica is 0.286 at 1,000 deg. C." The answer was that they represented the temperatures at which the specific heat was measured, and could obviously represent nothing else.

The testing machine for green sand, the necessity for which Mr. Buchanan queried, was built because no other compression machine capable of giving accurate readings at the low level required was available. The usual range required was about 200 grams (7 ozs.) on the A.F.A. testpiece or 2 ozs. per sq. in. The type of machine used also gave a very uniform rate of loading.

No specification for the viscometer was given as it was considered that the standardisation of such equipment was a matter for the Technical Committee of the Institute of British Foundrymen or some similar body, and Mr. Sheehan hesitated to give any dimensional details outside the authority of the above-mentioned committees.

* "Modern Sand Testing." See FOUNDRY TRADE JOURNAL, May 11, 1939, pp. 385-8.

Storage of Pig-iron Advocated

Mr. T. McKenna, of Middlesbrough, general secretary of the National Union of Blast-furnacemen, was a strong advocate of the storage of pig-iron at the annual conference of the Union at Bridlington. Complaining of the insecurity of employment in the pig-iron trade, he said that figures and other facts taken over any reasonable period of years showed that to go on producing in the lean years and putting tonnage aside to be drawn upon in times of boom or crisis, was not only practicable, but would also be of great benefit to the producers themselves and of inestimable value to the men employed at the blast furnaces, coke ovens, ironstone and coal mines. Referring to the slump at the end of 1937, he suggested that the producer should have realised that, owing to the rearmament programme, pig-iron was bound to be needed. He held that instead of dropping the number of operative blast furnaces in 1938 to 76, at least 115 could have been maintained in blast with profit and advantage to all concerned. The employers, he said, had since advised him that they were carefully examining the position, and there seemed to be some hope that something effective would be done.

Enamelling Shop Troubles*

By A. J. BIDDULPH

The enamelling process seems to be especially susceptible to technical troubles, many of them being due largely to the extent to which the human factor can make or mar a good job. Just as good shop organisation is evidenced by the regular flow of work from process to process, so the effectiveness of the control system will be shown by the lack of what are called "shop troubles." In a small shop the control will be probably applied by the master enameller, and will correspond to the more elaborate systems in the larger plant with the numerous instruments applied to control tests by men whose sole job it is.

All shop troubles may be traced to a breakdown in control at some point, *i.e.*, the specification has not been observed, either accidentally or wilfully: Accidentally, for example, when a fuser brings a load of ware out of the furnace too soon; wilfully, when the master enameller, being pushed for delivery, instructs the fuser to fire ware in a furnace that is not hot enough, or when common blackplate is used to fabricate an article because stocks of ingot iron have been allowed to run out.

The raw material specifications will state the essential requirements of the steel sheet or blanks, correct design, type and gauge of sheet iron, design and analysis of casting, qualities of frit, oxides, clay, etc., purity of water.

Process Specifications

Process specifications will deal with the different sections of the enamelling cycle:—

Pickling.—Cleaning, pickling and neutralising solutions, with limits of concentration, temperature, impurities and time cycle, with notes on renewal.

Mill Room.—Mill additions with weights of pebbles, time of grinding for each slip (or revolutions required), fineness, viscosity, temperature, mobility, methods of testing, inspection and renewal of linings and pebbles, and use of reclaimed enamel.

Application.—Dipping weight per sq. ft. and method of testing, temperature, angle of drain, variations in dipping practice.

Spraying viscosity, weight per sq. ft. coverage.

Fusing.—Temperature and approximate time for each class of ware, methods of stacking and notes on handling. These are positive instructions rather than a series of "don'ts."

Inspection.—Limits of colour, pass and not pass, allocation of work to "hospital" or rework.

Blasting.—Sizes and kind of grit—their renewal, air pressure, limits of nozzle size or r.p.m. of impact machine with grit sizes and blade renewal.

Crawling

This defect is due fundamentally to two factors:—(1) Initial cracking of biscuit when ware is placed in furnace, and (2) balling-up of the resultant pieces of enamel when fluid, due to high surface tension, coincident with low viscosity.

The first factor becomes a danger when the biscuit is not thoroughly dry, or is too thickly applied, or the slip has been too finely ground, giving differential shinkage in drying. It may persist where there is excessive thermal strain in the casting (or sheet). The second factor is more elusive. The surface tension of the enamel is that of the frit modified by the clay and oxides, and electrolyte added at the mill. Some oxides have a greater effect in raising the surface tension than others, and with normal grinding and normal clay addition much crawling may occur, even when thinly sprayed. This condition may be remedied in the shop by adding extra clay and so increasing the viscosity that surface tension cannot come into play. It is noteworthy that one rarely encounters crawling with acid-resisting enamels for cast iron.

Copperheads

The small brown pits usually found fairly evenly distributed over a part of the whole surface of a sheet may be divided into three classes:—

(*a*) Those caused by the parting of the very thin enamel coating over various small protuberances on the iron surface. In this case the enamel coating may be as thin as 1×10^{-4} instead of the normal 3 or 4×10^{-4}. If this trouble be intensified, a burned patch results. The remedy is obvious.

(*b*) Those caused by a very rough surface. When sheet iron is blasted with abrasive of the size used for cast iron, innumerable tiny ridges are thrown up all over the surface. These ridges may be up to 10×10^{-4} high, and are often 5×10^{-4}. When a normal coat of enamel is fired on this surface it is not thick enough to cover these ridges, which slag away the very thin coating of enamel. The remedies are:—(1) Blast with finer abrasive; (2) rub over the surface with hand stone (white stone and not dark stone), or (3) pickle instead of blasting. In any case *do not increase thickness of enamel.*

(*c*) The true copperhead is a brown speck which, upon close inspection, is resolved as a small crater of smooth slag about $\frac{1}{16}$ in. across, with a solid core of dull sinter. A very small copperhead may appear as a brown pimple $\frac{1}{64}$ in. across, rather higher than the surrounding enamel.

There are usually several of these copperheads fairly evenly distributed, and they occur on sheets normally pickled which have quite enough enamel coating. They may be multiplied by harder firing. The cause has been attributed to various factors:—

(1) Break in continuity of enamel, causing surface oxidation; this does occur, but has been dealt with earlier.

(2) Floating of iron scale in enamel. Where a plate has not been pickled clean, maybe where oxide has been rolled into a torn surface, copperheading may be found in lines coincident with the torn surface.

(3) Improper cleaning of iron. Pickling with acid having a high iron content (above say 8 per cent.) often results in copperheading on iron that does not show the defect when pickled with clean acid.

(4) Crystallisation of salts from enamel slip during slow drying, these isolated crystals flux very early in the fusing cycle and soon start to slag away the iron. It has been noticed that a badly rust-spotted plate tends to copperhead at the core of the rust spot. Generally, one may recommend better cleaning of the iron and avoidance of excessively strong slip liquor, but particularly a low iron content in the pickling acid.

Fuming, Sulphuring and Scumming

Fuming is due to incipient crystallisation of the outer skin of the enamel, and occurs when the enamel is held within the critical range of temperature for that particular glass. This temperature of crystallisation is very low for most enamels, far below that at which the melted enamel becomes rigid. However, with certain conditions of oxide and clay additions at the mill, this critical temperature is raised to within the range of semi-fluid enamel, and crystallisation may take place.

Firing conditions also contribute to affect this critical temperature. In a leaking muffle, which allows products of combustion to circulate around the ware, a colouring oxide that is not too stable may undergo chemical change sufficiently to cause the surface enamel to crystallise while within the fluid range. It is especially easy when enamel is applied as a dusty coat with a large surface area, instead of a wet coat with the minimum surface. This may be noticed on outside edges and corners, where the enamel tends to spray dry.

Scumming is somewhat different in its mechanism; one sometimes finds that, from incorrect suspension or from too great a water content, a little of the clay floats to the top of the slip. When this slip is sprayed, the clay floats to the surface, forming a scum of refractory material that does not glaze at the firing temperature of the enamel. Some oxides, notably light greens, behave in the same way. The scum may occur as a line or patch or as a fine network all over the surface. It is much accentuated by the deplorably bad habit of bumping a casting or plate to make rough spraying appear smooth.

Rust Spots on Cast and Sheet Iron

Rust spots are caused by an acidic state of enamel in contact with certain irons. With sheet iron, it has been found that the commercially-pure irons have less tendency to rust-spot than the less pure, higher carbon irons. In the case of cast iron the tendency to rust-spot varies for a given iron with different enamels, and also varies with a given enamel applied over different irons. The general remedies are: (1) rapid drying in *moving air*, and (2) use of suitable electrolyte (magnesium sulphate is fatal; sodium sulphate and acids are very bad). Sodium nitrite is widely used to prevent rust-spots and forms the chief constituent of many proprietary preparations for the purpose. Borax, sodium persulphate and sodium phosphate are also used. The great advantage of $NaNO_2$ is that it has very little effect on the set of the slip (0.04 per cent. of the frit up to 0.05).

Hairlines

These are caused by the fracture of the ground coat due to excessive mechanical or thermo-mechanical strain. In the first case, accidental distortion of a sheet after firing, maybe after the cover coat is dried, can be detected and remedied by routine shop organisa-

* Paper presented to the Institute of Vitreous Enamellers in Manchester.

tion, though here again, with proper control, it would not occur. In the second place, the strain due to differential expansion between parts of one article is much more difficult to correct. It is a common fault in cheap hollowware, hairline occurring on the body of the piece around the boss of the handle, *e.g.*, saucepans and jugs. The fault is also experienced on some cooker parts, where heavy steel lugs are sometimes welded on the back of light-gauge plates, and wherever one finds concave square cut corners. This latter often develops into splitting of the cover coat from the ground coat.

The true remedy lies in redesigning the piece to avoid these strains, though often this will be beyond the enameller. Although hairlines are usually a sheet-iron fault, they occur also in cast-iron wet-process enamels; here, again, faulty design is the chief cause, but often the fault is intensified by too heavy an application of enamel.

One may say definitely that hairlines are due to uneven expansion between different parts of the enamel base. In a casting there is often a great difference in section in adjacent parts, and unless precautions are taken to even up the heating by reinforcing or weighting the lighter section, hairlines may occur. With sheet iron, strains set up during forming will tend to cause hairlines. Any lugs welded on the back of a sheet are very conducive to the formation of hairlines, but it occurs at times on even sections of sheet when forming has been done without thought for the enameller. The front corners of sheet crown plates are a well-known example. Cold, heavy firing tools will cause stars and hairlines on sheets, and sometimes on thin sections of castings. *Very hot tools* also make stars.

Black Specks

Black specks are the bugbear of any sheet enamellers and not unknown to those working on cast iron. Most specks are caused by shop dirt, from general dust arising from the floor, from brushing tables, from black edge sprays, from furnace door and structure, from roof trusses when sparrows fly around, from oxide scale within the furnace disturbed by cold ware going in, and from many other sources. In many shops compressed-air lines of blowers are provided for blowing dirt off the ware when it is loaded, and *sometimes* these are used.

Specks have been traced also to dirt from black rubbing stone, contamination of enamel slip by organic matter in the clay, dirty water in the mill, dirty water used in the quenching bosh, and broken pebbles in the mill; also from minute reboiling of the ground coat. On cast-iron dry-process enamels, black specks have been traced to zinc particles scraped from the galvanised enamel containers. The best slogan for any enamelling shop is "*CLEANLINESS.*"

Blistering on Cast Iron

It is usually held that blisters are due to evolution of gases around the temperature of firing enamels, CO and CO_2 being the gases most often indicated. Krynitsky and Harrison hold that blistering is caused by the micro-chill which occurs in grey-iron castings forming cementite, which later breaks down under heat-treatment, and is more readily oxidised than ordinary graphite, producing CO_2 which may continue up to the full firing time of the enamel. If the evolution of gases is completed before the enamel is fully fired, then there is a good chance of the blisters healing over.

In support of this is the widely-held opinion that annealing helps to prevent blistering, and thorough blasting to remove the surface layer of iron is standard practice. Other workers hold that the evidence for micro-chill is only circumstantial and other causes have been put forward, such as gas absorption at the time of pouring, dirt inclusions, uneven thickness and porosity in the metal.

The Bureau of Standards in 1930 investigated samples of two different castings which gave serious trouble in production. In one case there was found a spongy texture in the iron underneath the blister. In the second, the casting was a steel-iron mixture with 1.2 per cent. silicon and a highly eutectic structure and excessive amount of very finely divided graphite. It was believed that this finely divided carbon was readily oxidisible during firing. The trouble was eventually corrected by reducing the steel scrap and increasing the silicon content.

In view of what has been said about micro-chill, it may be interesting to mention an experiment carried through in production recently. A casting of a general section about $\frac{3}{32}$ in. had three heavy lugs about 1 in. thick which invariably showed some blistering, not on the heaviest part but where the section changed from thin to thick. After many attempts to find a cure, both in the enamelling department and in the moulding shop, a core was used to lighten the heavy section, but some blistering still occurred at some place on 90 per cent. of the castings—often where there was a slight draw on the surface due to unequal cooling. As it was seen that the light sections were not blistering and that these sections were quickest to cool in the mould, it was thought that if a chill could be used against the heavy lugs a structure somewhat approaching the lighter section could be obtained. This was done, and the results were surprisingly good, and in that shop the localised blistering on heavy sections was almost eliminated.

It would thus appear then that this micro-chill is not, of itself, the cause of blistering. Most enamellers would agree that heavy sections are a fruitful source of localised blistering. Apart from these theoretical considerations it is found in practice that blistering occurs coincident with (*a*) incorrect moulding practice; (*b*) incorrect annealing, or (*c*) insufficient blasting.

(*a*) *Poor moulding-shop practice* is a very common trouble, especially with jobbing enamellers, whose customers cannot or will not adapt their moulding practice to make their castings suitable for enamelling. In many of the large cooker works where the enamelling department is but one of several, the management have found it is sound economics to insist on the moulder and patternmaker giving castings suitable to the enamelling practice. Where this is not the case, the enameller can avoid much trouble by agitating for suitable castings, at the same time being sure that his own shop is beyond reproach.

(*b*) *So-called annealing* prior to blasting is standard practice in most shops, though where a matte ground coat is used, annealing is in some cases considered unnecessary. Where annealing is practised, however, much trouble can ensue if the temperature is too low to soften the micro-chill, or if it is so high as to allow of excessive oxidation. All that is required is 20 to 30 min. at a temperature about 20 deg. higher than the highest firing temperature of the enamel to be applied. The casting should be blasted and enamelled within 36 hrs. of annealing. To anneal a casting and then to leave it lying around for several days so that it can absorb moisture is seeking trouble. Localised blistering is often attributed to this cause.

(*c*) *Insufficient blasting* is the most common cause of general blistering. Several factors combine to make this so, and amongst these are the following:—(1) The men usually engaged are not of the best type, *or they would not be blasting*. Usually the job is piecework, which encourages high output, but supervision of a blaster at work is neither easy nor pleasant. (2) It is very difficult to detect a half-blasted casting. If a part has been missed altogether it can easily be picked out, but once the surface is roughened it is very difficult to see how much blasting has been done to the iron. (3) In a mistaken effort to cut down expenses, some plants use a comparatively soft iron abrasive which quickly loses its cutting edge while retaining its particle size. Thus a normal blasting with such an abrasive will not give a clean surface, and continued blasting will tend to peen the surface with resultant blisters.*

Fishscaling

Fishscaling occurs when, owing to insufficient iron oxide solution, the ground coat has not attained a coefficient of expansion approaching that of the iron base. However good the ground-coat enamel, it cannot provide a safe foundation for a cover coat unless it is applied at the proper thickness on a suitable surface and fired correctly. Most of the causes attributed to fishscaling have their effect through retarding iron oxide solution, *e.g.*, bright-rolled iron and under-pickled iron each present a closed surface to the enamel. Too hard an iron will have pearlite over an appreciable area, thus reducing the ferrite available for oxidation during fusing.

Too low a fusing temperature does not allow oxidation to proceed with the speed attained at the higher temperature. Owing to the lesser fluidity of the enamel there is not so much opportunity for diffusion of oxide through the enamel layer, and too heavy an application of enamel acts in the same way. The oxide has a much greater mass of enamel to diffuse through and its effect on the coefficient of expansion is that much less. A leaking muffle obviously retards any oxidising reaction. Generally, one may say that fishscaling occurs when two or more of these factors coincide, though with underfiring it may occur when all other factors are up to specification. Fishscaling is one of the troubles which well illustrate the effects of a departure from process specification.

Materials and process specification may be looked upon as embracing the fundamentals of successful enamel-shop practice, gathered as the result of practical experience. Just as in football, the best game is the one in which rules are strictly adhered to, so in enamelling tranquility is assured when the shops are running to specification and dangerous short cuts to success are avoided.

Enamelling News

THE PRESIDENT ELECT

Prof. J. H. Andrew, D.Sc., Dean of the Faculty of Metallurgy, Sheffield University, has been nominated by the Council of The Institute of Vitreous Enamellers to succeed Sir Harold Hartley, F.R.S., who vacates the chair at the next annual meeting after having held office for two years. The nomination is peculiarly appropriate as Prof. Andrew is extremely enthusiastic in advancing the technique of foundry practice and his department is particularly well equipped both for teaching and research. His interest in sheet steel is also well known, and research work on many phases of its properties is constantly in progress at Sheffield University. He is the immediate Past-President of the Sheffield Branch of the Institute of British Foundrymen and has served on the General Council for a number of years. Apart from his academic experience, the professor has held important executive positions in industry.

Research

The Institute is making good progress with its research programme through the Joint Committee, which includes representatives of the B.C.I.R.A. This committee is presided over by Mr. J. W. Gardom, who has a wide experience of this class of work. Initially, a bibliography of all scientific work undertaken upon vitreous enamelling was prepared and more recently a test has been developed for establishing a method for ascertaining the acid-resisting properties of enamels. A full description of the proposed method will be presented to the annual conference to enable members to check the results so far achieved and to establish a general concordance of results under the widest conditions of application.

* See "Investigation into the Use of Metallic Abrasives," by J. E. Hurst and W. Todd, FOUNDRY TRADE JOURNAL, December 1, 1938, p. 408, *et seq.*

Investigation and Modern Ideas on Enamel Control

By G. H. ABBOTT, B.A. (Oxon), A.I.C.

(*Concluded from page* 18.)

The importance of the microscope in the study of enamel reactions was recognised by E. E. Geisinger in 1922, and for the first time attention is drawn to the possibility of examining enamels in cross-section. Geisinger observed the effect of furnace gases on enamels, and noted the results of over- and under-firing. In a study of bubble formation he remarked that a high viscosity in enamels does not allow the ready escape of gases, but results in the formation of large bubbles and a weak structure. The effect is well illustrated in Fig. 14. A large reboiling bubble is present at the surface of the iron, and the photograph shows the enamel lifted completely above it.

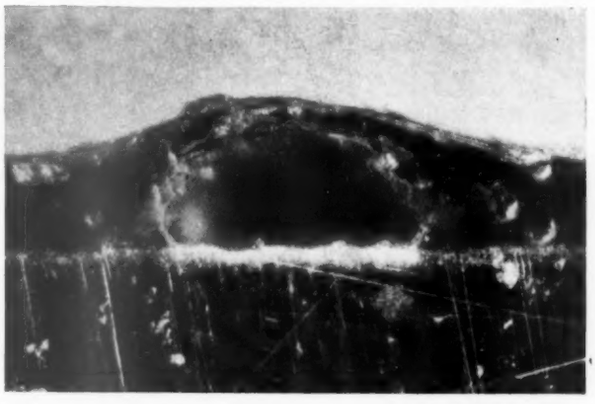

FIG. 14.—PHOTOMICROGRAPH OF CROSS-SECTION OF ENAMEL DEFECT. × 100.

The defect commonly known as a copperhead is illustrated in Fig. 15. The photomicrograph clearly shows the crater left by the escape of a large bubble, and the stream lines indicating excessive solution of the iron. Figs. 16 and 17 are other cross-sections of the same enamel. When the large bubbles in the ground coat have broken, they become filled with the cover-coat enamel, resulting in a weak structure. In both cases the ground coat is nearly saturated with iron oxide.

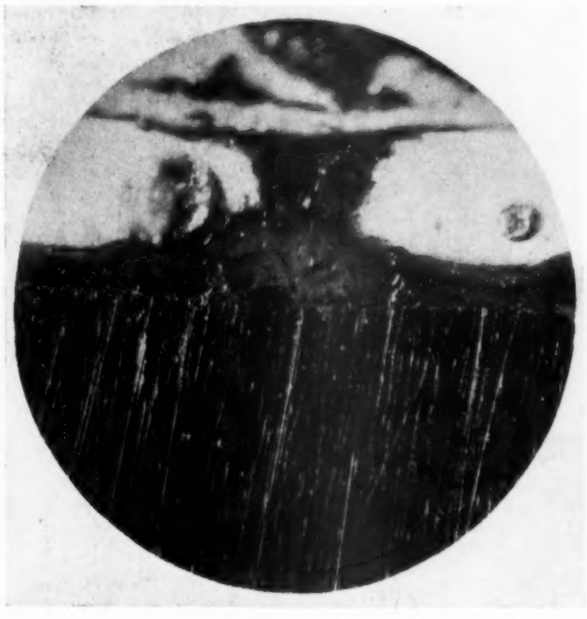

FIG. 15.—PHOTOMICROGRAPH OF CROSS-SECTION OF ENAMEL COPPER-HEAD. × 250.

Physical Tests

Two testing machines have been designed by National Enamels, Limited. In the impact machine (Fig. 18) the metal ball is released from a small electro-magnet. In the bending machine the test-strip is placed between two steel jaws and gradually bent until fracture occurs, observations being made on both sides of the strip.

The results obtained in the laboratory and problems arising from the works frequently need examination under conditions of actual practice. A pilot plant is the most useful means of carrying out such projects. A plant of this type recently completed at National Enamels,

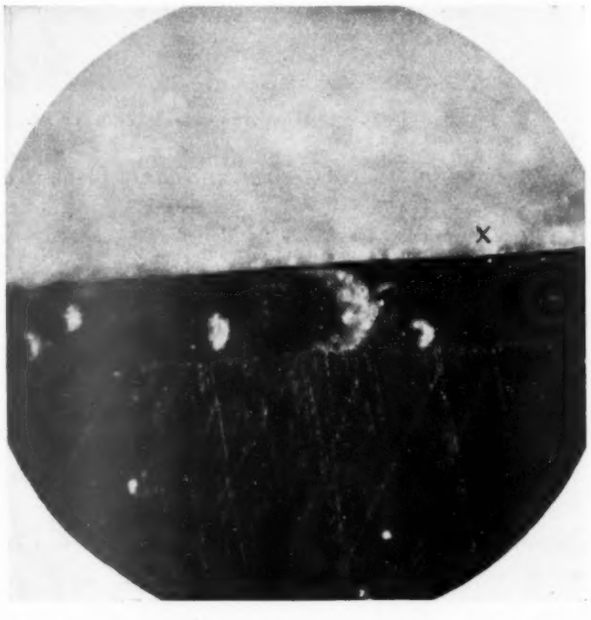

FIG. 16.—PHOTOMICROGRAPH OF ENAMEL SECTION. × 250.

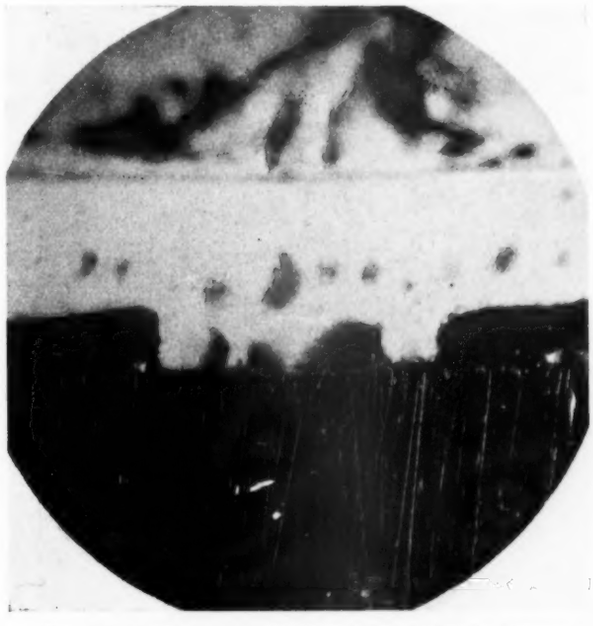

FIG. 17.—PHOTOMICROGRAPH OF ENAMEL CROSS-SECTION. × 2,250.

Limited, is illustrated in Figs. 19 to 22. All investigation and development can be carried out here without interruption of the manufacturing process, and proved results can be transferred confidently to works scale.

In a recent lecture to the Institute of Chemistry, Dr. Hatfield said: "The operation of a large number of individual private research centres is the best possible means for ensuring the introduction of new ideas into the steel industry, and of encouraging individual research workers to bring forward their ideas." It is hoped that some of the points raised in this Paper will encourage new methods of research and control in the enamelling industry.

The author is indebted to the directors of National Enamels, Limited, for their permission to present this Paper, and to Mr. H. G. Fry, the works manager, for his co-operation and for the loan of photomicrographs. Acknowledgment is also made to Dr. J. H. Partridge and Mr. R. W. Douglas, of the General Electric Company, Limited, for their information on coefficients of expansion of enamels; to Mr. A. Bunce, of United Glass Bottle Manufacturers, Limited, for his determination of viscosities; and to Mr. Norman and Miss Thompson, of the South Metropolitan Gas Company, for their preparation of lantern slides. The results of Dr. S. H. Bastow are also appreciated.

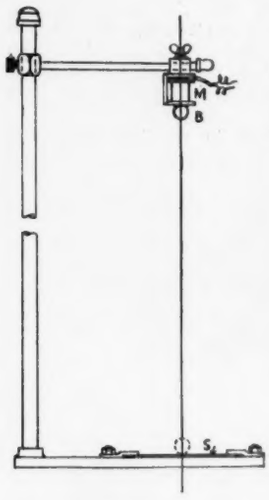

Fig. 18.—Impact Testing Machine.

Fig. 19.—Mixing Apparatus.

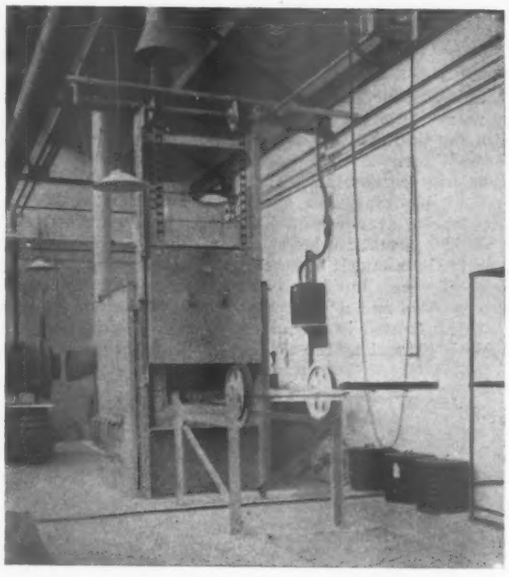

Fig. 23 (Right).—View of Semi-Scale Laboratory showing Pilot Fusing Furnace.

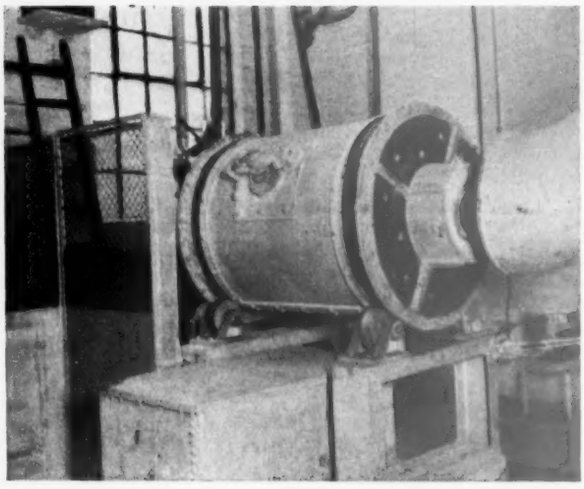

Fig. 20.—Pilot Rotary Smelters.

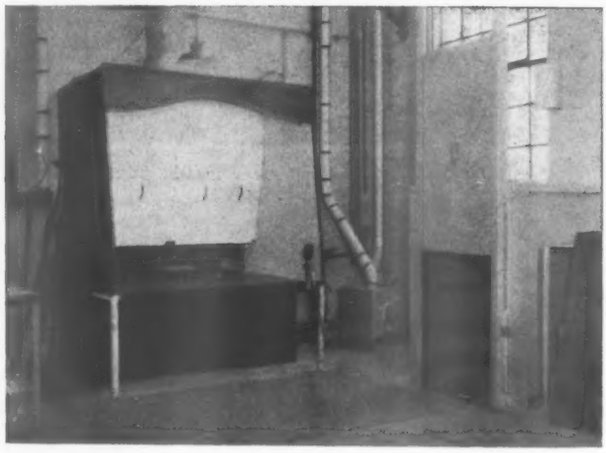

Fig. 22.—Spraying Apparatus and Drying Oven.

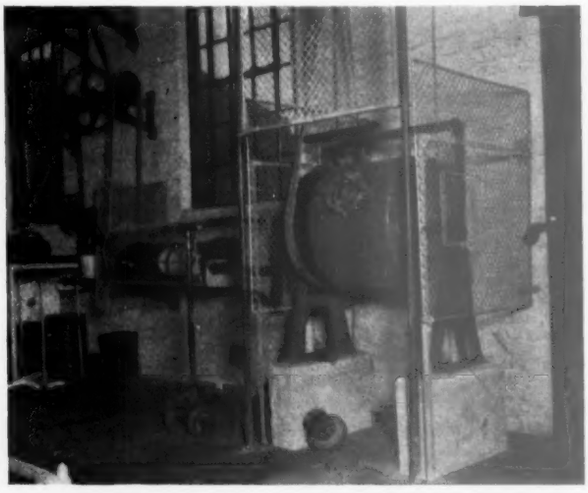

Fig. 21.—Pilot Milling Apparatus.

Obsolete Iron and Steel Plant in U.S.A.

Since 1926 the United States steel industry has abandoned or dismantled a total of 173 blast furnaces, 39 plants for producing steel ingots and 144 plants for producing finished iron and steel products, according to the American Iron and Steel Institute. Substantially all of the plants which were abandoned or scrapped had been rendered obsolete or inefficient by the improved technology of steel and iron production. Fewer than a dozen plants were abandoned as a direct result of mergers or consolidations. The decline in productive capacity from the abandonment of obsolete plants has been more than offset by the construction of new and more efficient plants and by the modernisation of existing facilities. As a result, the industry's present capacity for producing steel is 30 per cent. greater than in 1926, while its capacity for producing pig-iron, which has become relatively less important as a steel-making material, has remained steady. Between 1926 and 1938, 14 new blast furnaces were built, averaging 2½ times the capacity of the furnaces abandoned during the period. In addition, 12 entirely new steel-ingot plants and 42 new plants for producing finished steel have been constructed since 1926.

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The Week's News in Brief

Trade Talk

OWING to a local shortage of moulders, South Yorkshire iron foundries are searching in Scotland for skilled men.

THE CLAY CROSS COMPANY, LIMITED, have started a new blast furnace at their ironworks at Clay Cross, Derbyshire. It has an output capacity of 1,000 tons per week.

MR. GEORGE USHER, managing director of International Combustion, Limited, is reported to have expressed the hope of opening an engineering works in South Wales in conjunction with a Government scheme, but no details are yet available.

A SCHOLARSHIP TENABLE at Sheffield University and provided by the English Steel Corporation, Limited, for the session 1939-40, has been awarded to Mr. Maurice William Buttler, of Sheffield, who is engaged in the foundry department of the Grimesthorpe works of the company.

THE BRIGHTSIDE FOUNDRY & ENGINEERING COMPANY, LIMITED, Sheffield, have obtained a contract from the Aluminium Company of Canada, Montreal, P.Q., for aluminium rolling-mill plant for their new factory. This plant comprises a hot reversing breaking-down mill and six stands of sheet-finishing mill rolls complete with reduction gear sets.

THE PARTNERSHIP between Messrs. R. T. G. W. Trotter, A. H. Dodgson and William Dodgson, carrying on business as boiler manufacturers and ironfounders at Greatham Street, West Hartlepool, under the style of Homogeneous Metals Process Company, has been dissolved by mutual consent upon the sale of the business to the Home Metals Radiant Boiler Company, Limited. Debts will be received and paid by the company.

JAPAN has been taking over 2,000,000 tons of scrap metal from America in each of the last few years, and it is calculated that that import accounts for about 50 per cent. of Japan's steel production. At the same time, an embargo imposed by the termination of the Commerce and Navigation Treaty, as appears probable, would make considerably larger quantities of scrap available for the European nations, and with a notable reduction in competition.

CONTRACTS for eleven more Admiralty vessels have been placed with Clyde firms—four boom defence vessels, six trawlers, and a dredger. The boom defence vessels and dredger will be built and engined by Lobnitz & Company, Renfrew, who have on the stocks a large dredger for the Admiralty. In recent years this firm has built and engined a number of boom defence vessels. Six trawlers will also be built. This latest series brings the number of Admiralty vessels ordered from Clyde yards up to over 70. There are only nine firms on the Clyde with no Admiralty work.

EIRE'S NEW STEEL WORKS at Haulbowline, County Cork, according to present arrangements, will go into production on August 24. The works, the construction cost of which is estimated at £750,000, will, it is anticipated, be capable of producing in the year 20,000 tons of black sheets and galvanised iron, 16,000 tons of tinplate and 30,000 tons of squares, angles, channels and girders, and when in full production will employ from 900 to 1,200 men. The directors hope to provide the entire national requirements. The chairman of Irish Steel, Limited, is Mr. David Frame, so well known in Dublin in connection with the work of the Hammond Lane Foundry, of which he is managing director.

On Monday last, Capt. R. S. Hilton, managing director of the United Steel Companies, Limited, lit the first of the two new blast furnaces built in connection with the big extension scheme now nearing completion at the works of the Appleby-Frodingham Steel Company, Limited, at Scunthorpe. The furnace, which is about 200 ft. high overall, is capable of producing 3,500 tons of pig-iron per week, using the local Frodingham ironstone; and it is interesting to note that if the new furnace were smelting American ores, which have a much larger iron content, it could turn out 1,000 tons of pig-iron per day. The second furnace of similar design is expected to be blown in shortly. Other equipment included in the scheme comprises a battery of 66 coke ovens and equipment for crushing, sintering and blending the local ores. Shortly we hope to publish a full description of this important plant.

Personal

Mr. George Sands, foreman moulder with the Carron Company, Falkirk, has retired after 56 years' service.

MR. J. I. WILLIAMS, lecturer in metallurgy and electro-plating at Birmingham Central Technical College, has been appointed lecturer in metallurgy and chemistry at the Constantine Technical College, Middlesbrough, where he will begin his duties in September.

Mr. Colin Cuningham Scott has been appointed chairman of Scotts' Shipbuilding & Engineering Company, Limited, Greenock. He is a cousin of the late Mr. R. L. Scott, whom he succeeds, and has been a director of the firm for more than 20 years, having been appointed to the board in 1916. He was formerly deputy chairman of the company. Mr. James Hamond Hoare-Scott, nephew of the late Mr. R. L. Scott, has been appointed a director of the company.

Wills

MASON, WILLIAM, late of Mason & Burns, Limited, malleable ironfounders, of Walsall	£44,927
DOVE, WILLIAM, of York, managing director of William Dove & Sons, Limited, ironfounders, etc.	£81,231

Obituary

ENGINEER VICE-ADMIRAL SIR ROBERT DIXON has died whilst on a visit to Australia, at the age of 72, after an illness lasting three weeks. After a brilliant career in the Navy, Sir Robert joined the board of directors of a number of engineering firms, including Babcock & Wilcox, Limited; Clarkson Thimble Tube Boiler Company, Limited, and G. D. Peters, of Slough. He held office in a number of scientific and technical associations, including the Institute of Metals.

MR. PETER MACGREGOR, who for many years was a leader in the industrial and commercial life of Sheffield, has died in London, at the age of 73. He was a former chairman and managing director of Sanderson Bros. & Newbould, Limited, was a past-president of the Sheffield Chamber of Commerce, and for six years was chairman of the Sheffield district of the Federation of British Industries. For years he was a member of the executive committee of the National Federation of Iron and Steel Manufacturers.

Company Reports

Blythe Colour Works, Limited.—Interim dividend of 5 per cent. on the ordinary shares.

Herbert Morris, Limited.—Dividend for the half-year to July 31 on the 5 per cent. (free of tax) cumulative preference shares.

Vickers, Limited.—Interim dividends of 2½ per cent., less tax, on the preferred 5 per cent. stock, 2½ per cent., less tax, on the 5 per cent. preference stock, and 2½ per cent., free of tax, on the cumulative preference stock.

James Howden & Company, Limited.—Net profit for the 10 months ended April 30, £80,457; brought in, £1,402; to general reserve, £20,000; A.R.P. expenditure reserve, £7,500; dividend of 15 per cent.; carried forward, £18,659. Meeting, August 2.

Contracts Open

Birmingham, August 28.—Cast-iron stairs, wrought-iron gates and grilles, bronze grilles, copper ventilators, etc., for the Town Council. Mr. F. H. C. Wiltshire, town clerk, Council House, Birmingham, 1. (Fee £2 2s., returnable.)

Bradford, August 24.—Special pipes and castings; steam and gas tubing and fittings, wrought-iron and steel; wrought-iron and steel bars, plates; brass main gas cocks, etc., during 12 months ending September 30, 1940, for the Town Council. The Gas Engineer, Britannia House, Bradford.

Company Meetings

Head, Wrightson & Company, Limited

The acquisition of a shipyard site adjoining their main works was reported at the annual meeting of Head, Wrightson & Company, Limited, on Tuesday, at Teesdale Ironworks, Thornaby-on-Tees. SIR GUY WRIGHTSON, BT., who presided, said that the land and a number of the buildings comprised in this purchase were well suited to their purposes and provided the additional accommodation which had become essential to meet the expansion of their business. It had also enabled them to centralise their laboratories. The proportion of their turnover which was attributable directly and indirectly to rearmament work had increased during the past year, but was still a comparatively small proportion of their total turnover. They were in course of erecting a small subsidiary works in the South Durham Special Area to make alloy steel forgings, where they hoped to get into production in a few weeks' time. They continued to spare no effort to increase their export business. Their South African subsidiary completed during the year its first accounts as a manufacturing company, and the results were satisfactory. All departments had been actively employed during the year, and their order-book was in a satisfactory condition.

W. & T. Avery, Limited

Presiding at the annual meeting of W. & T. Avery, Limited, held at Birmingham on Tuesday, SIR J. FORTESCUE FLANNERY, BT., said that they were continuing their policy of modernising their production facilities. The new steel fabrication department was now in full working order. The machinery, both at their chief works at Soho Foundry in Birmingham and at the various branches used in manufacture and repair, had been steadily maintained, and new machine tools provided as required.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

506,878. SIEMENS & HALSKE AKT.-GES. Compressed powder magnetisable cores.

506,905. KRUPP AKT.-GES., F. Manufacture of parts of chemical apparatus and other articles from chromium-manganese steel alloys.

506,957. KUDO, H., and KOBE SEIKOSHO COMPANY, LIMITED. Impact testing-machine.

507,057. LUMB, C. F. Preparation of impermeable corrosion-resisting coatings.

507,113. SOC. ANON. DES TUBES DE VALENCIENNES ET DENAIN. Manufacture of seamless tubes in a pilger step rolling-mill and product obtained.

507,172. FABRIKS-A. B. HALDATAXAMETERN. Machines for cutting or shearing metal plates and the like.

507,195. FABRIKS-A. B. HALDATAXAMETERN. Machines for cutting or shearing metal plates and the like.

507,200. BRASSERT, H. A., and BRASSERT & COMPANY, LIMITED, H. A. Bessemer converter.

507,262. LINDE AIR PRODUCTS COMPANY. Apparatus for conditioning billets and other like semi-finished steel shapes by means of oxidising gas streams.

507,277. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER. Production of iron powder.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Richard Cramp & Sons, Limited, Unit Works, New North Road, Hainault, Ilford.—Capital, £1,000. Engineers, founders, etc. Directors: R., R. G. W., and B. Cramp.

Test Valley Iron Works Company, Limited, 123, The Hundred, Romsey, Hants.—Capital, £5,000. Iron and brass founders, etc. Directors: W. J. and W. J. H. Gascoigne.

WM. CUMMING
AND COMPANY LIMITED

IRONFOUNDERS' FACINGS MANUFACTURERS AND GENERAL FOUNDRY FURNISHERS

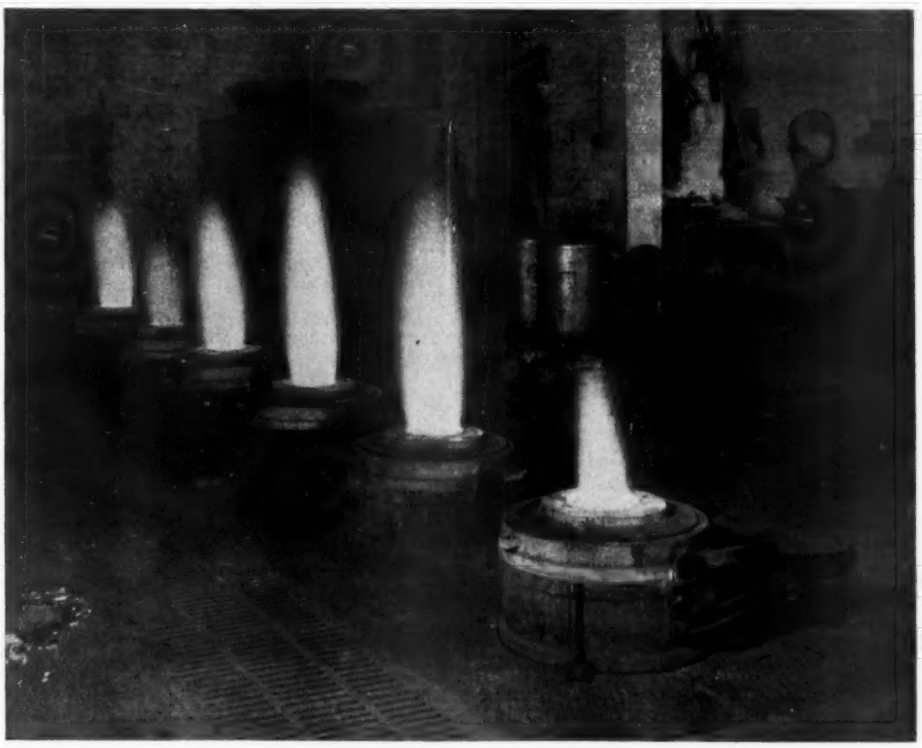
OUTSTANDING SUCCESSES

CUMMING SHALAGO BLACKINGS

The CUMMING MOULDING MACHINE

The CUMMING SAND MIXER

The CUMMING ELECTRIC RIDDLE



CUMMING CORE COM-POUNDS

PLUMBAGO Imported direct from Ceylon

The CUMMING FURNACE

A Battery of six in full blast.

(By courtesy of the Coronium Metal Co., Ltd., Reading).

Head Office and Works—

Kelvinvale Mills, Maryhill, GLASGOW.

Branches at

FALKIRK, CHESTERFIELD, DEEPFIELDS AND MIDDLESBROUGH.

LONDON OFFICE: SENTINEL HOUSE, SOUTHAMPTON ROW, W.C.1.

Raw Material Markets

The demand for iron for steel-making purposes is fully maintained, but business in foundry pig-iron continues to be on the quiet side, with few prospects of an early improvement. The steel industry is working to capacity and delay is experienced in the despatch of certain descriptions. The scrap market is now easier following the arrival of substantial tonnages of steel scrap from the United States, but additional material would find a ready market.

Pig-Iron

MIDDLESBROUGH.—The foundry pig-iron trade in this district remains very dull; consumers' limited requirements are not always being bought from local producers, substantial tonnages being obtained from the Midlands, so that the quietness of the trade is thus accentuated. Ironmasters are very active on the production of iron for use in the steelworks, but the decline of the business in Cleveland iron is not welcomed, as the time will come, no doubt, when the effect of this will be more acutely felt.

Hematite makers' stocks have been considerably reduced during the past few weeks and trade since prices were lowered on July 1 has been very active. Local buyers had allowed their stocks to fall to a very low level and this has necessitated their purchasing on a large scale. A fair demand has also been received from steelmakers in South Wales and deliveries to that quarter have been heavy. Thus, the negligible demand from overseas is causing little inconvenience, but every effort will be made to stimulate export trade as soon as the opportunity arises.

LANCASHIRE.—A moderate forward booking movement in foundry pig-iron is noticeable in this area and some consumers have satisfied their potential requirements up to the end of the year, but, on the whole, users are not placing orders for more than current needs. The light-castings foundries have had a very disappointing season, while most jobbing founders continue to be rather badly situated for new orders. Heavy electrical engineers and machine-tool manufacturers, on the other hand, have been busy for some time past and the outlook in these sections is satisfactory. Most other consuming trades, however, are not well placed. The hematite trade continues to be well supported and the call for contract deliveries is insistent.

MIDLANDS.—Steel-making irons remain in active request, and both hematite and low-phosphorus irons are taken up in heavy tonnages, largely against existing commitments. The lower quotations for hematite have induced buyers to enter the market during the past few weeks and substantial parcels are regularly changing hands. Consumers of iron with a low-phosphorus content generally have covered their requirements over some time ahead, and deliveries are being called for satisfactorily. The demand for high-phosphorus iron, on the other hand, is still at a low ebb; buyers mostly hold contracts, but deliveries are not being made as freely as would be desired.

SCOTLAND.—Conditions in this area have now returned to normal following the holiday interruptions, but trade in foundry iron continues to be within narrow compass. The light-castings trade should now be entering upon its quiet period, but, in reality, there appears to be little difference in the condition of this important foundry-iron consuming industry at any time of the year, and short time has been prevalent throughout the months when works should normally be operating at full capacity. Iron for the steelworks is moving away satisfactorily.

Coke

Consumers of foundry coke have continued to maintain an active interest in new business during the past week, and many users have now covered their requirements up to the end of the year. For delivery to Birmingham and Black Country stations until December 31, the minimum price of both Durham and Welsh coke will be 50s. 6d. per ton.

Steel

Reports from all the steel-producing areas state that the current demand far outstrips the available supply. One of the most active sections of the industry is the sheet-bar trade, which is engaged on the production of shelters under the A.R.P. programme, but, in spite of extensive imports of bars from abroad, additional supplies would be put to immediate use. The demand for joists and sections is fully maintained, and there is considerable delay in the rollings of specified descriptions. In many instances, steelmakers have arrived at the position when it is impossible to state a firm date for delivery.

Scrap

The tone of the iron and steel scrap trade generally is rather easier, owing to the arrival of further supplies from abroad. Nevertheless, all available tonnages of steel scrap are readily disposed of at firm prices. The demand from the steelworks appears to be insatiable, and while the cost of imported scrap increases production expenses, these are willingly incurred. Ironfoundries, on the whole, continue to call for cast-iron scrap on a heavy scale, but supplies are ample to meet current requirements.

Metals

The London Metal Exchange will close for the Bank holiday after the morning session on Friday and will reopen on Tuesday morning.

Copper.—There has been quite a firm undertone in this market during the past few days, but industrial demand for copper may be expected to fall away to some extent in the near future, owing to the imminence of the holiday period. Nevertheless, the usual slackening off is not likely to be so pronounced this year, as the demand for copper in connection with the manufacture of armaments will be fully maintained, while many other consumers have not in recent times covered their requirements very substantially, owing to the unsettled outlook. World stocks of refined copper are expected to decline still further during the next quarter. Following the American Government's decision to terminate the Treaty of Commerce, which was signed in 1911 with Japan, there has been a very heavy Japanese demand for American copper. This, no doubt, is a precautionary measure against an American embargo on exports of copper. Japan, which is the largest market for copper from the United States, took about 39 per cent. of American exports during the first five months of this year.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £43 1s. 3d. to £43 3s. 9d.; Friday, £43 3s. 9d. to £43 6s. 3d.; Monday, £43 8s. 9d. to £43 11s. 3d.; Tuesday, £43 15s. to £43 16s. 3d.; Wednesday, £44 to £44 1s. 3d.

Three Months.—Thursday, £43 7s. 6d. to £43 8s. 9d.; Friday, £43 10s. to £43 11s. 3d.; Monday, £43 13s. 9d. to £43 16s. 3d.; Tuesday, £43 18s. 9d. to £44; Wednesday, £44 5s. to £44 6s. 3d.

Tin.—Only a small amount of business continues to be done, and speculative interest in the metal is negligible. The buffer pool continues to maintain prices at around £230 per ton for cash metal. A report from Amsterdam states that the Second Chamber's reception of the revised Bill concerning the fusion of the Banka and Billiton tin mines is generally again unfavourable, the majority of members desiring that the Bill be referred back to the Netherlands Indies People's Council for reconsideration.

According to the July issue of the "Statistical Bulletin" of the International Tin Research and Development Council (Statistical Office, 21, Prinsessegracht, The Hague, price 1s.), the total stocks of tin, comprising visible supply and smelters' stocks, at the end of June amounted to 39,387 tons, against 43,823 tons at the end of May, a decrease of 4,436 tons, or 10 per cent. In June, smelter deliveries amounted to 9,827 tons, as compared with 11,377 tons in the preceding month. World production in May totalled 9,600 tons, bringing the total for the first five months up to 54,100 tons, against 70,400 tons in the corresponding period of last year. World apparent consumption in May is estimated at 13,500 tons, and the total for the first five months at 63,400 tons, against 69,700 tons last year. World tinplate production in May is estimated at 376,000 tons. Production in the first five months amounted to 1,547,000 tons, being an increase of 22 per cent. as compared with the corresponding period of last year. The table on tin stocks in this month's "Bulletin" has undergone material change, and now includes, in addition to figures for the visible supply, the total stocks with the principal smelters. The additional information will afford a better insight into the statistical position of the metal.

Mr. W. H. Gartsen (Henry Rogers, Sons & Company) announces that the total visible supply of tin on July 31 was 22,654 tons, against 22,774 tons on June 30. The carry-over in the Straits Settlements was 2,167 (1,208) tons, while the carry-over at principal European smelters (other than British Tin Smelting Company) was 3,570 (4,849) tons.

Official quotations were as follow :—

Cash.—Thursday, £229 17s. 6d. to £230; Friday, £229 17s. 6d. to £230; Monday, £229 17s. 6d. to £230; Tuesday, £229 17s. 6d. to £230; Wednesday, £229 17s. 6d. to £230.

Three Months.—Thursday, £225 2s. 6d. to £225 5s.; Friday, £224 17s. 6d. to £225; Monday, £225 to £225 2s. 6d.; Tuesday, £225 2s. 6d. to £225 5s.; Wednesday, £225 to £225 5s.

Spelter.—Business in the United States of late has been quite heavy, and the price has been advanced 10 points to 4.60 cents per lb. The weekly market report issued by Rudolf Wolff & Company states that "a fairly active demand on the part of consumers is reported and the improvement in this direction in the last weeks has contributed to the very firm undertone which is consistently maintained."

Daily market prices :—

Ordinary.—Thursday, £14 6s. 3d.; Friday, £14 10s.; Monday, £14 11s. 3d.; Tuesday, £14 11s. 3d.; Wednesday, £14 10s.

Lead.—This market continues to be quite firm, and available supplies are readily taken up. Consumption by most users is satisfactory. Prompt tonnages are not too plentiful.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 16s. 3d.; Friday, £14 16s. 3d.; Monday, £14 18s. 9d.; Tuesday, £15 5s.; Wednesday, £15 8s. 9d.

Scrap.—Reduced activity during the past few days has been largely attributable to holidays.

Complimentary Dinner to Mr. Hurst

Mr. J. E. Hurst was the guest of honour last Thursday at a complimentary dinner at the Grand Hotel, Birmingham, to mark the honour recently conferred on him by Sheffield University. Mr. Hurst was given an honorary degree of Doctor of Metallurgy. The dinner was given by the directors of Bradley & Foster, of which firm Mr. Hurst is technical director.

Mr. Hurst's research work, carried on continuously for twenty-five years, recently led to important discoveries in connection with the heat-treatment of cast iron, and in development of cast iron suitable for nitrogen hardening. Mr. Hurst joined the Institute of British Foundrymen in 1914. He has been its President, and was awarded its Oliver Stubbs gold medal in 1932, and its E. J. Fox gold medal last year.

Mr. R. W. Hale (chairman of Bradley & Foster) presided, and the toast of "Our Guest" was proposed by PROFESSOR D. HANSON (Professor of Metallurgy, Birmingham University), who said that the degree bestowed on Mr. Hurst was one given only to men of exceptional merit, and in Mr. Hurst they honoured one who deserved high reward. They knew his record and honoured his name.

Acknowledging the toast, MR. HURST said he was happy to recall that on the day he received his degree at Sheffield, his daughter received a degree of LL.B. at Birmingham University; and he was proud to think that his honour had been regarded by brother metallurgists as a worthy one, and as a reflection of the work being done in the sphere of cast iron. People had said that in cast iron there was a decadent industry, but he did not agree. Research constantly revealed that cast iron continued to be of great importance in the field of engineering.